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THE

RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. III JANUARY, 1922 NO. 1

Editor:

PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.

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PHILIP R. COURSEY, B.Sc., F.Inst.P., A.M.I.E.E.

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SUBSCRIPTION RATES.—£3 per annum, post free. Single copies, 5/-, or post free, 5/3.

Vol. III. No. 1 — Registered at the G.P.O. for transmission by Magazine Post to Canada and Newfoundland. — JANUARY, 1922

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THE
RADIO REVIEW

VOL. III. JANUARY, 1922 NO. 1

Editorial.

Earthing Systems *versus* **Insulated Counterpoises.**—To earth or not to earth has been the question since the earliest days of radiotelegraphy and that it is still a burning question was shown by the discussion which followed the reading of Mr. T. L. Eckersley's paper on Transmitting Aerial Resistances at the Wireless Section of the Institution of Electrical Engineers on December 7th. The insulated counterpoise, or earth screen, certainly appears to be coming into its own. From the earliest days there have been those, notably Sir Oliver Lodge, who have supported its claims against the earthed antenna. Lodge in his Royal Society paper in 1909 said: "The present trouble is caused by the utilisation of the earth as one terminal of the aerial system both in sender and receiver. I do not expect this to be immediately admitted, but so it is—at any rate at land stations." "It is better to ignore the earth and work independently of it both at the sending and receiving end, taking care to keep everything insulated." Poulsen and Pedersen, guided by a true instinct, installed an insulated counterpoise at some of their arc stations, but it is only during the last year or two that the advantages of the valve transmitter, combined with the limitations in the power produced by a single valve, have forced upon radio engineers the fact that the range of a station does not depend on the power put into the aerial but on the current in the aerial and its effective height. Given these, the smaller the power the better.

It would be of interest to learn what proportion of the 3,600 kW which de Groot proposes to put into the Java arc is going to be radiated and how much is going to be utilised in heating the gorge in which it is installed.

As was mentioned in the discussion, Meissner has recently described at the Jena Congress * a method of decreasing the earth losses by an extensive system of small earth plates or stakes distributed in a proper manner and with wires running overhead to each. He stated that it was expected in this way to increase the radiation efficiency of the Nauen aerial from 7·5 to about 50 per cent. It remains to be seen whether these expectations will be realised, but it is interesting in that it appears to be something of a compromise between the counterpoise and the earthing system.

It is interesting to note that the Marconi Company have installed insulated counterpoises at Carnarvon and Clifden both of which have aerials of the inverted L type, designed to have directive properties. It was shown fairly

* See *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 322—337, November, 1921.

conclusively by Hoerschelmann that the directive action of such an aerial is due to currents induced in the earth below the aerial. This is now confirmed by Mr. Eckersley's admission that the counterpoise has practically destroyed the directive effect of these aerials. It is an open question, however, whether the small amount of directive action actually obtained was ever worth the dissymmetrical design with its consequent increased losses as compared with a **T** aerial of the same total span.

The Paris International Conference.—Very little has been published concerning the proceedings of the Conference on radiotelegraphy which was held at Paris during the past summer. We do not know to what extent the proceedings were regarded as confidential and it may be that the members themselves have divergent views on this point. Italy was fortunate in having as one of her representatives Professor Vallauri of the Italian Naval College at Leghorn, whose work in so many branches of radiotelegraphy is well known. We have heard several of the delegates express the opinion that he was one of the outstanding personalities of the Conference and it is therefore with great pleasure that we publish a translation of a communication which he has sent to us giving not only an outline of the technical decisions arrived at but at the same time his own personal views and criticisms of many of the points.

In his introductory remarks he states that the Conference expressed the wish that the technical decisions should be published in order to invite collaboration and criticism. We are therefore furthering the objects of the Conference by publishing these notes.

In dealing with nomenclature Professor Vallauri laments the difficulties arising from the natural affection of any one for a term or phrase of which they regard themselves as the parent. The difficulties in any one language are great enough, and they are intensified enormously when one has to find a term which will meet with universal acceptance. When once an International Conference, however, upon which we are duly represented, decides upon a certain nomenclature, we feel that it is the duty of all writers and editors to adhere as far as possible to the decisions arrived at. It would prove a difficult task, however, to eradicate the use of the word " aerial " in favour of antenna as advocated, or to call every D.F. set a radiogoniometer.

Professor Vallauri's criticisms and suggestions on the subject of the definition of the equivalent decrement of an emission will prove of great interest. The conventional ideal resonance curve is based upon assumptions which do not apply to actual emissions and there is a certain latitude in the choice of the equivalent ideal. We agree with Professor Vallauri that much requires to be done in the development of methods of measurement before any serious attempt can be made to apply at all rigorously rules and regulations based upon the lines indicated. In dealing with the nominal range, the method adopted was that which we have previously employed in the RADIO REVIEW, namely, to calculate from the ordinary Hertzian formula, with the Austen-Cohen attenuation factor, the strength of the electric field produced at the receiving station and to specify a certain strength of field as standard for a given type of reception. In the present state of our know-

ledge the Conference were probably well advised to adopt this simple criterion of range. The latter part of the paper deals with the organisation of an international radiotelegraphic research association, a matter which had been taken up before the war and which arrangements are now being made to resuscitate.

The Opening of the New York Radio Central.

Radio Central is the name given to a high-power wireless installation which is now being erected by the Radio Corporation of America near Port Jefferson, Long Island, about seventy miles from New York. The station is designed for international wireless telegraphic communication, and has been planned by the engineers of the Radio Corporation of America, in con-

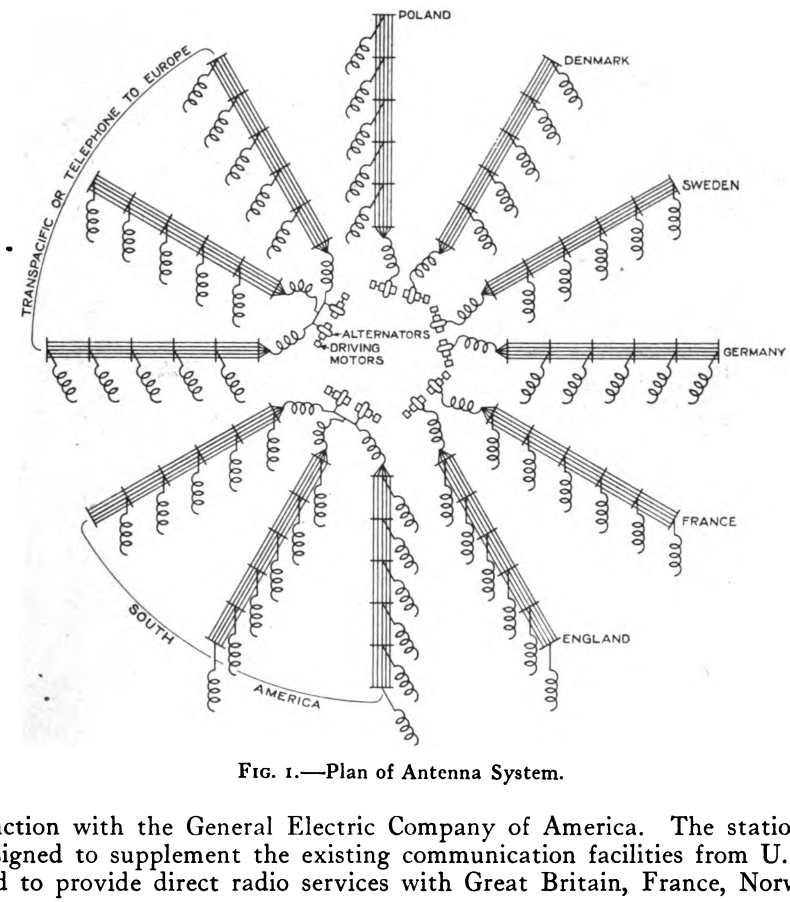


FIG. 1.—Plan of Antenna System.

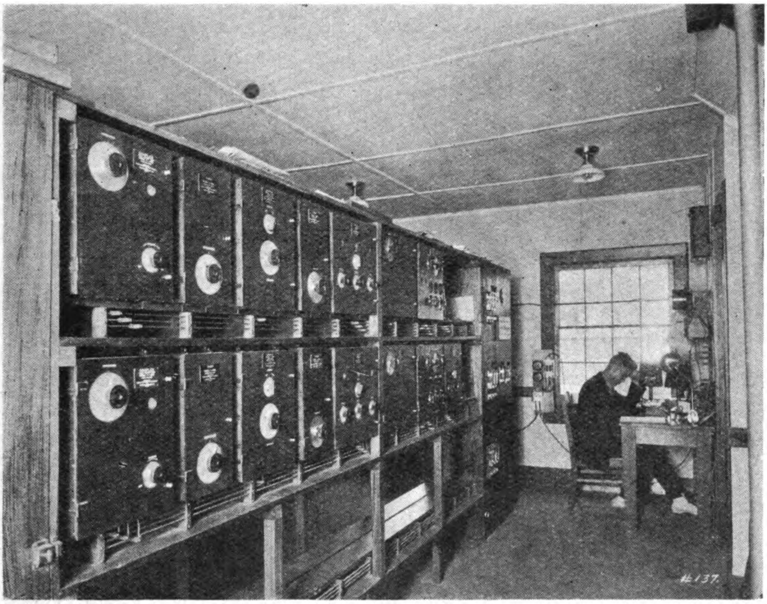
junction with the General Electric Company of America. The station is designed to supplement the existing communication facilities from U.S.A. and to provide direct radio services with Great Britain, France, Norway,

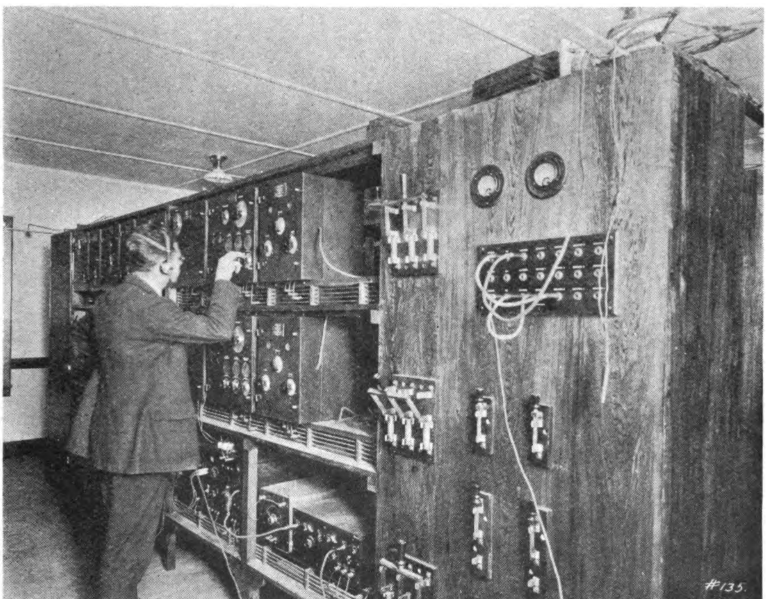
Germany and other European countries as well as to South America. The site of the station occupies an area of some 6,400 acres and the station will eventually consist of a number of separate antenna systems each provided with the necessary transmitting plant for simultaneous radio communication over a number of different routes (Fig. 1).

In the pioneer days of high-power radiotelegraphy a station functioned

FIG. 2.—Exterior View of Receiving Station at Riverhead, L.I.

alternately as a transmitter, a receiver and a telegraph office. This involved much loss of time and greatly reduced the traffic facilities, for a station had to stop sending while it received, and *vice versâ*. It therefore became apparent that the ideal radio station should comprise three separate but closely connected units operated by remote control, these units comprising respectively the transmitter, the receiver and the central traffic office, the latter preferably in the heart of the business district in large cities.





FIGS. 3 and 4.—Two Views of the Receiving Apparatus at Riverhead Station. Each shelf contains all the units necessary to receive from one European station.

FIG. 5.—Operating Room at the Central Traffic Office, New York.

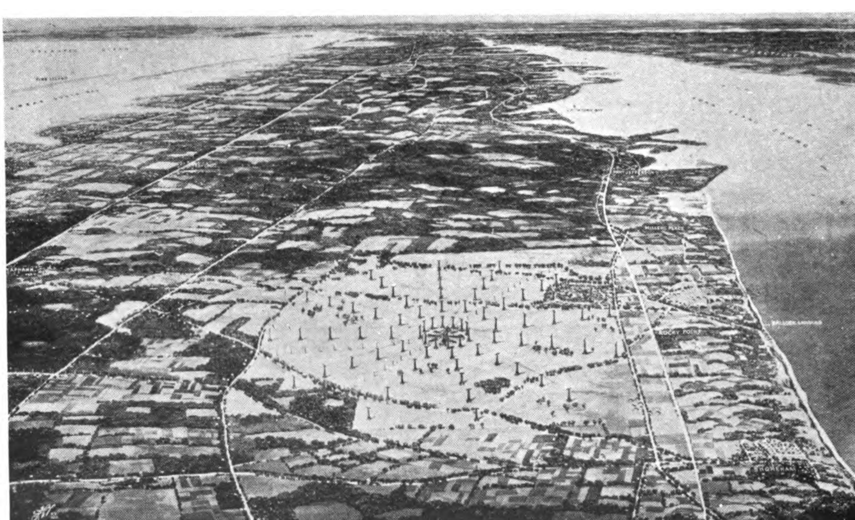


FIG. 6.—Bird's-eye View of Arrangement of Station.

In the case of the New York Radio Central, the first two of these units are located at Long Island and the third in New York City. The transmission plant is located at Rocky Point, some seven miles east of Port Jefferson, on the northern shore of Long Island. The receiving station (Figs. 2 to 4) is at Riverhead, L.I., about sixteen miles from the transmission plant, and has been so planned as to be able to receive simultaneously messages from

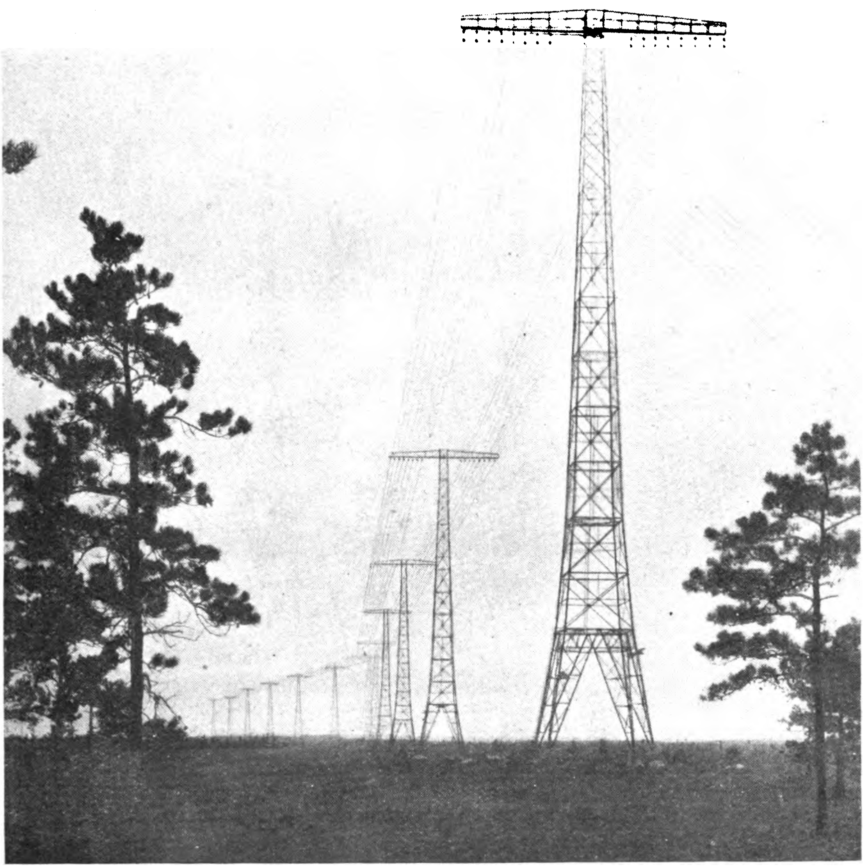


FIG. 7.—The First Twelve Towers of the Aerial System. The six in the foreground form Antenna Arm No. V., and the other six Arm No. XI.

as many countries as can be communicated with simultaneously by the transmitting station. The central traffic office at 64, Broad Street, New York City, is fitted with special remote control apparatus for operating the transmitters direct from that office. The incoming signals picked up at the Riverhead receiving station are also automatically transferred over the landlines to the central traffic office. The incoming signals can there either be transcribed by ear or automatically received on recording apparatus. The operating room in New York is shown in Fig. 5.

The construction of the Radio Central Station was commenced in July,

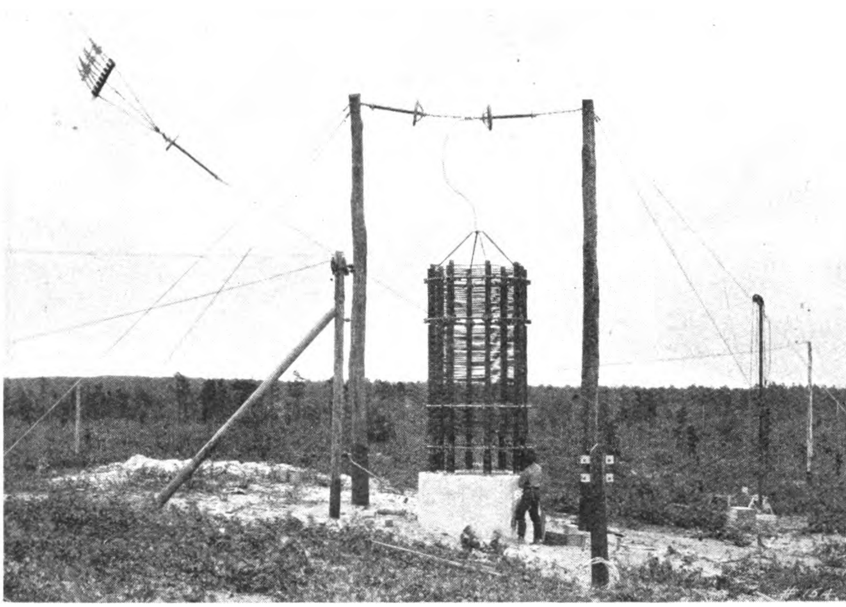


Fig. 8.—One of the Twelve Multiple Tuning Coils.

1920, and the first test signals from the first part of the station were sent out in October, 1921. This is considered to be a record in the building of high-power equipment, considering the great amount of work that has been carried out on the station.

The aerial transmitting system was originally planned to comprise twelve arms for the various communication routes, these arms radiating out from the central power house like the spokes of a wheel. A diagram giving a bird's-eye view of the station as originally planned is reproduced in Fig. 6. Up to the present two arms of the aerial system have been built, each arm having six towers 410 feet in height. The distance between adjacent towers is 1,250 feet, giving a total of nearly three miles from end to end of the line

of twelve towers already erected (Fig. 7.) Each tower required nearly 150 tons of steel, the total amount used in the twelve being 1,800 tons. The cross-arms from which the antenna wires are suspended on the top of each tower are each 150 feet long. The steel work incidental to the construction

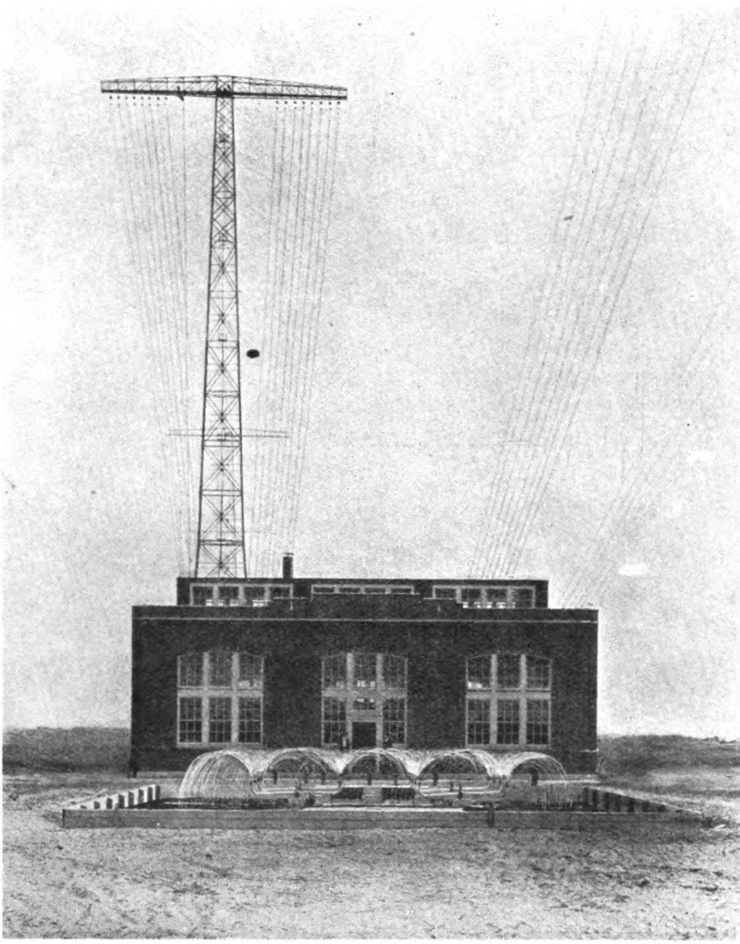


FIG. 9.—Front View of Power House, showing the Cooling Pond in the foreground.

of the towers and station buildings was erected by the American Bridge Company under the supervision of the J. C. White Engineering Corporation of New York. The 23,000 volt transmission lines by which energy is supplied to the station run from Port Jefferson, a distance of seven miles, and were erected by the Long Island Lighting Company. The control lines

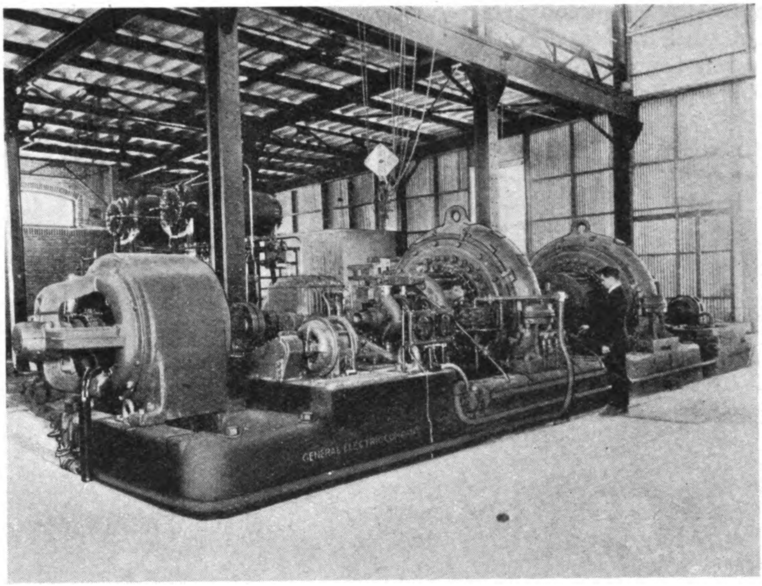


FIG. 10.—Two 200-kW Alexanderson Alternators.

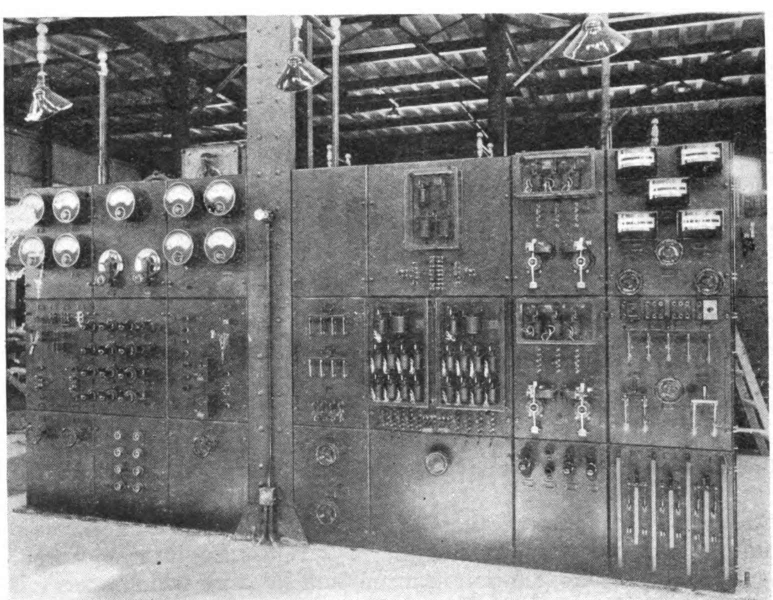


FIG. 11.—Switchgear and Control Panels in the Power House.

between the transmitting and receiving stations and New York City were erected by the New York Telephone Company.

Each antenna is of the Alexanderson multiple-tuned type—*i.e.*, it is provided with several earth connections along its length, each connection

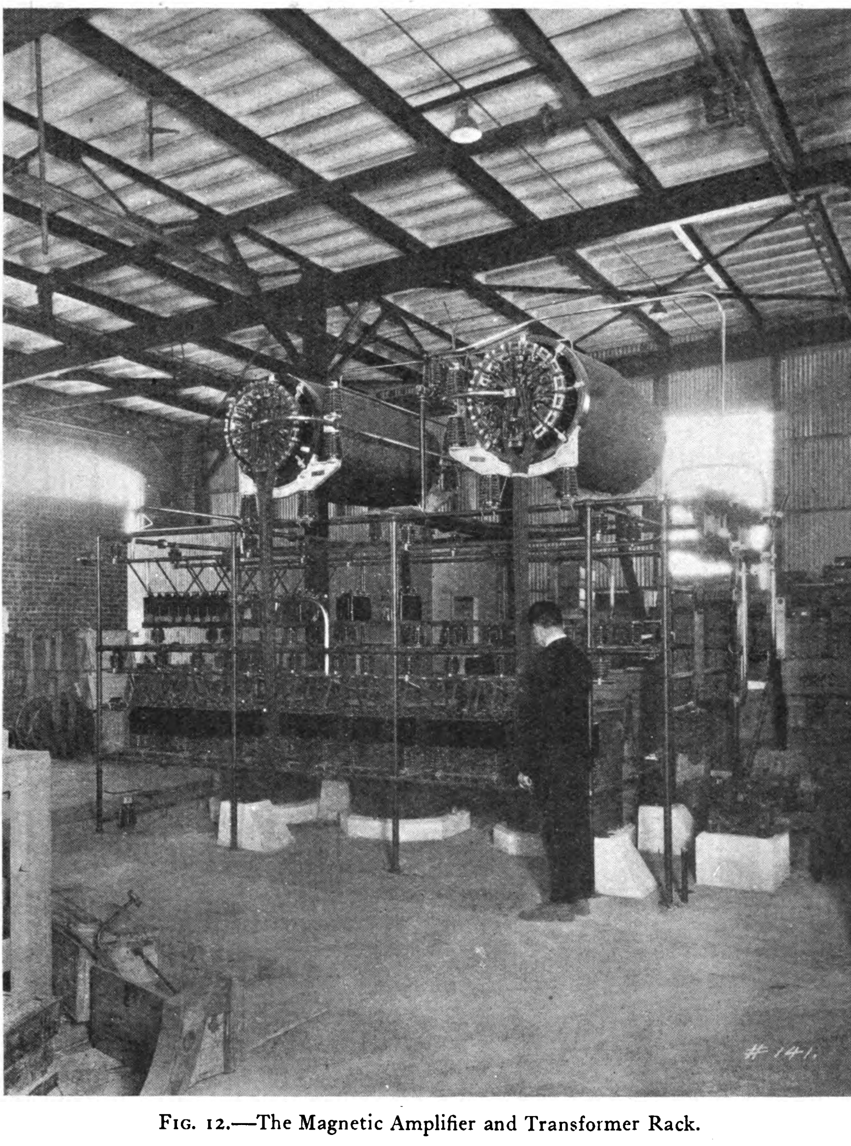


FIG. 12.—The Magnetic Amplifier and Transformer Rack.

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RADIO CORPORATION OF AMERICA

EDWARD J. NALLY, PRESIDENT

"VIA RCA" "VIA RCA"

Send the following Radiogram "VIA RCA", subject to terms on back hereof, which are hereby agreed to. } Check No.

THE WHITE HOUSE
WASHINGTON

United States of America.

To be able to transmit a message by radio in expectation that it may reach every radio station in the world, is so marvelous a scientific and technical achievement as to justify special recognition (stop) It affords peculiar gratification that such a message, from the Chief Executive of the United States of America, may be received in every land, from every sky, by peoples with whom our nation is at peace and amity (stop) That this happy situation may ever continue, and that the peace which blesses our own land may presently become the fortune of all lands and peoples, is the earnest hope of the American nation (stop)

Warren G Harding

November 5, 1921

FULL-RATE RADIOGRAM UNLESS MARKED OTHERWISE

FIG. 13.—Reproduction of President Harding's Opening Message.

including a tuning coil. As may be seen from Fig. 8, these coils are set up in the open air.

The foundations for the twelve towers necessitated the use of 8,200 tons of concrete since the base of each tower leg is sunk 9 feet below the ground level and has a base area of 360 square feet.

For the construction of each arm of the antenna sixteen stranded silicon-bronze cables, $\frac{3}{8}$ inch in diameter, are used, fifty miles of this cable having been employed in the two above-mentioned antenna arms. Four hundred and fifty miles of copper wire have already been buried in the ground to form the earthing system. The erection of the remaining arms of the whole antenna system is now being proceeded with and will eventually comprise seventy-two towers.

The first power-house section is located in the centre of the tower line, shown in Fig. 7, and covers a space of 130 feet by 60 feet (Fig. 9). It accommodates two 200-kW high-frequency alternators with auxiliaries and equipment (Fig. 10). These machines, with the necessary switchboard, tuning coils, etc., were built by the General Electric Company of America, and each is capable of a continuous output of 200 kW at any wavelength between 15,800 and 20,000 metres.

The control panels and switchgear at the power station are illustrated in Fig. 11. Signalling is effected by means of Alexanderson magnetic amplifiers. These with their auxiliary condensers can be seen in the lower part of Fig. 12, which also shows the high-frequency transformers mounted on the upper part of the structure. Their use permits of a signalling speed of 100 words per minute for each of the transmitting units, so that the equipment at present completed is thus capable of despatching traffic at the rate of 200 words per minute.

The station was formally opened on November 5th by President Harding, who sent out a message addressed to every radio station in the world. The radiogram form showing the message is reproduced in Fig. 13. The reports of the reception of this opening message and of the preliminary test signals have shown that the range of the station is practically world-wide since its signals have been heard in all parts of Europe, in Australia, in South America and in Japan.

The Community House for the staff is a low one-storeyed building containing sixteen single rooms, an official suite, a large living-room and dining-room, as well as quarters for servants, the engineer-in-charge with a staff of fifteen assistants, comprising the *personnel* at present necessary to maintain the station in operation. The final installation will include ten Alexanderson high-frequency alternators which, when all operating together, will give a total power output of 2,000 kilowatts.

Notes on a Direct-reading Radio Direction Finder.*

By ALESSANDRO ARTOM.

1. General Considerations.

In these notes I intend to describe a new class of appliances which solve an interesting problem in wireless telegraphy and especially in radiomechanics. The aim of these appliances is to place in the radiotelegraphic stations, a pointer or index to show the direction from which the radiotelegraphic signal comes. In my earlier works on the direction finding of electric waves † I have described several methods and appliances by means of which the direction of the radiotelegraphic station which transmits the signals can be ascertained. But in these radiotelegraphic systems the indication of the direction is given by the observation of the greater or lesser intensity of the telephonic reception, so that their use requires operators of special ability.

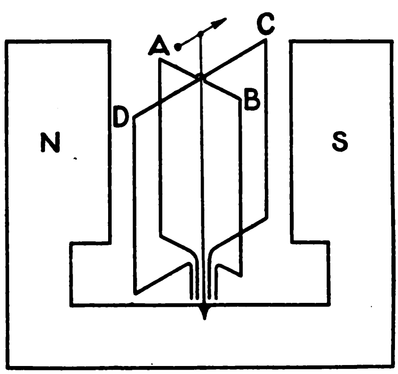

FIG. 1.

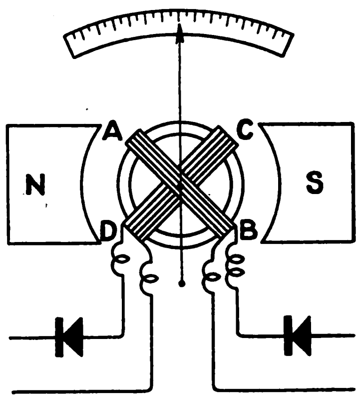

FIG. 2.

In the various appliances which are the subjects of these notes,‡ the direction from which the signal comes is automatically indicated, by simply reading the deviations or movements of a pointer, without the need of special observations. Figs. 1 and 2 represent in plan and elevation one of the forms in which these appliances can be constructed. The received radio-

* Received August 15th, 1921.

† **A. Artom,** *Proceedings of the Accademia dei Lincei*, Turin, March 15th, 1903; February 5th, 1905; June 17th, 1906; January 3rd, 1915; January 7th, 1917. *Acts of the It. Electrotechnic Ass.*, 1908.

‡ *British Patent* of March 27th, 1916; *Italian Patent* of February 9th, 1917, and corresponding foreign patents.

telegraphic currents are picked up by two directive aerials or receiving frames, sometimes at a right angle but more generally at an arbitrary angle. These currents are rectified by means of one of the methods well known in radiotelegraphy, such as thermionic valves, crystal contacts, etc., and are sent into two galvanometer coils AB, CD, arranged either at right angles or at an angle equal to that between the directive aerials. The coils are electrically insulated, but mechanically connected to each other and attached to a pivot so as to constitute one single movable system which can rotate around a vertical axis. A sufficiently strong magnetic field NS, is provided, so that when the currents are flowing through the coils, there is a deviation of the movable system. Owing to the well-known properties of directive aerials, I shall demonstrate that the angle of deviation of the movable system of such an apparatus is a function of the angle between the direction of the incoming signal and the base of one of the receiving directive aerials. Apparatus based on the principles explained above can be constructed in different forms. One of these (Fig. 3) is particularly adapted for laboratory measurements, and is also adapted to the study of the theoretical conditions of working. It is somewhat analogous to the thermo-galvanometer of Boys and Duddell.

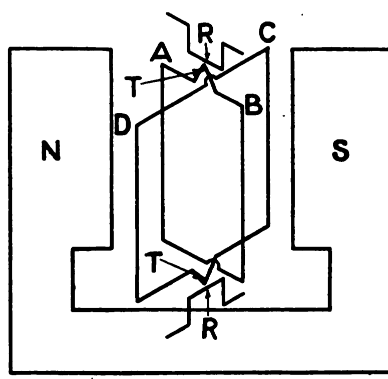

FIG. 3.

Both the galvanometer coils are provided with thermoelectric contacts TT, and the currents coming from the directive aerials are passed through two suitable resistances RR so as to act, by Joule effect, on the thermoelectric elements. In this way, currents proportional to the effective values of the intensities of the receiving currents are generated in the galvanometer coils. A magnetic field, NS, of sufficient strength causes the deviation of the movable system. The value of the angle of deviation of this movable system is dependent upon the direction in which the transmitting station is situated.

In fact, if we call i_1 and i_2 the currents of the orthogonal directive aerials, it is well known that if α is the angle which the junction of the point of intersection of the direction aerials makes with the base of one of them, whose projection we assume as axis of x, we obtain

$$\left.\begin{aligned} i_1 &= K_1 \cos\alpha \\ i_2 &= K_2 \sin\alpha \end{aligned}\right\} \qquad (1)$$

If we call i_1 and i_2 the currents which by Joule effect circulate in the galvanometer coils and δ the deviation of the movable system under the action of the magnetic field, the equation of equilibrium is,

$$HS_1 i_1' \sin\delta = HS_2 i_2' \cos\delta \qquad (2)$$

where H is the intensity of the magnetic field, and S_1S_2 the constants of the galvanometer coils. From (2) we obtain

$$\tan\delta = \gamma \frac{i_2'}{i_1'}, \text{ where } \gamma \text{ is a constant,}$$

and from (1) :—

$$\tan\alpha = \frac{K_2}{K_1} \cdot \frac{i_2}{i_1} = K \frac{i_2}{i_1}.$$

By the well-known properties of proportionality between the thermo-electric currents generated in the galvanometer coils and the effective values of the currents circulating in the heating resistances, and calling μ a constant, we obtain :

$$\tan\gamma = \mu \tan\alpha \quad \ldots\ldots\ldots\ldots \quad (3)$$

that is to say that the angle through which the movable system of the apparatus is deviated is a function of the angle α made by the line connecting the transmitting station with the receiving one, with the horizontal projection of one of the receiving directive aerials.

2. Practical Apparatus.

The same principle leads to the creation of various types of appliances having a practical character to which the theoretical conceptions explained above are applied approximately, bearing in mind the variable coefficients due to the constructional form. These appliances of industrial type must therefore be subjected to experimental calibration and graduation. Among the constructive forms of a practical nature, I shall bring to mind the one represented by Figs. 1 and 2 which I have already mentioned in these notes. In the magnetic field, NS, two galvanometer coils are suspended at an angle to one another. They may also be placed one below the other.

The received currents after having been passed through the circuits to thermionic amplifying valves are conducted by means of light silver wires to the galvanometer coils. The thermionic valves are specially adapted for the types of apparatus which are the subject of the present notes, because they present the possibility of obtaining currents of considerable intensity. It must be noted that in order to attain good conditions of working it is necessary that the two thermionic valves be of equal sensibility. To this purpose I have invented a particular form of thermionic receiver, that is to say, a double valve. Round a central filament of circular form a cylindrical plate is placed, and in the electronic field thus constituted, are placed the grids and plates representing respectively the extremes of the rectified circuits of the currents which are circulating in the aerials.

The electronic field being common to both the currents, the physical conditions of equality of the amplifying and rectifying effects can thus be verified precisely.

A third class of apparatus is based on electromagnetic action in place of the magnetoelectric. In this new class of apparatus, the directing field is provided by two fixed coils placed at angles and traversed by rectified currents received from the directive aerials. In the vertical axis of symmetry

of this magnetic field, the movable system consisting of a double astatic needle of magnetic material is placed.

The physical fact of being able, by means of radiotelegraphic waves, to control at a distance even of many kilometres, the movement of a pointer in such a way as to cause it to be placed according to a determined direction, I hold to be fruitful of a practical application, as there is no doubt that these appliances can be rendered useful to navigation by sea and air, and in railway signalling.

R. Polytechnic of Turin.

Notes on the Technical Decisions of the Paris International Conference on Radio Communications (June—August, 1921).*

By Professor G. VALLAURI.

A technical committee consisting of American, British, French, Japanese and Italian delegates met at Paris during last summer to deal with a certain number of questions formulated during the preliminary conference at Washington in 1920.† The Committee expressed the wish that the more strictly technical decisions adopted by it should be made known through the scientific press and thus be submitted to the criticism of the specialists of every country whose collaboration in the study of the numerous problems still unsolved would be thus promoted. It appears opportune to fall in with the wish of the Committee and to explain concisely some of the more important questions dealt with, in the confidence that technical Italians will direct to them their study and continue it in such a way as to maintain, as they have hitherto maintained, a very notable position in the development of the science of radio communications. Of this desired collaboration it is also sought to give modestly an example in this note endeavouring to make here and there a critical examination of the arguments brought forward.

RADIOTECHNICAL NOMENCLATURE.

By the very necessity of drawing up an account of its deliberations the Paris Committee found itself face to face with the problem of nomenclature. It was not attacked completely as too much time and too much labour would have been necessary. However some agreements were reached, under the form of proposals that must be considered by the International Electrotechnical Committee which as is known has already been occupied from time to time with the problem of nomenclature.

(1) In place of "wireless telegraphy" and names derived from this, it is

* Received October 15th, 1921.

† *L'Elettrotecnica*, 8, p. 559, September 15th, 1921 ; *Bollettino Radiotelegrafico*, 2, No. 16.

proposed that the prefix *radio* be used, as well as the names *radiotelegraphy*, *radiotelephony*, *radiocommunicators*, *radiotechnics*, etc.

(2) For the so-called "parasitics," or "statics" or "X," and in general for all the electromagnetic phenomena which obstruct radiotelegraphic reception, and are not produced by other signallings but derived from natural causes the name *atmospheric disturbances* is proposed, which may be abbreviated to *atmospherics*. For the disturbances derived on the other hand from other signallings it was not possible to come to concordant decisions; it would appear however that the name of "interference" must prevail, and to indicate the greater or less ability of a given emission to disturb other receivers, that of "power of interference."

(3) For the terms "valve," "lamp," "audion," etc. the preference has fallen on the generic name of *electronic tube* which in the most common case of the usual tube with three electrodes becomes *triode*, to which can be joined, according to the three principal functions, the adjectives *rectifying*, *amplifying*, *generating*.

(4) For the methods of coupling between circuits are proposed the terms *coupling by resistance*, *by induction* (in some cases by *self-induction*) and *by capacity;* not excluding, it is understood, the possibility of mixed couplings that belong to more than one category simultaneously.

(5) For the apparatus that serve to determine the direction of propagation of the waves is recommended the name of *radiogoniometer*.

(6) For the conductor or the system of electric conductors utilised for sending out or for receiving the electromagnetic waves the name of *antenna* has been preferred to that of aerial. It is intended to exclude from the signification attributed to "antenna" the mechanical supports of the conductors.

(7) These mechanical supports are called *towers* if they are not protected against the wind, *pylons* or *masts*, if they are wind-protected (according as they are with lattice-work or not).

(8) For the antennæ with closed circuit (coil antennæ) the name of *frame antenna* or simply *frame* has been agreed upon.

(9) The half length of the dipole equivalent to a given antenna (with regard to the radiation in the superior hemisphere with respect to the surface of the ground) will be called *the radiation height* and the product hI of this height into the intensity of current at the base, will be expressed in metre-amperes using the symbol $m \times A$ (not mA = milliampere).

(10) If as is seen with regard to some points it has been possible to reach agreement upon concrete proposals it must be recorded that many other points of considerable importance for nomenclature have not been able to be defined. This is not surprising since in the matter of nomenclature many students are excessively preoccupied with scruples of purism and of the absolute suitableness of the words selected, or even with questions of *amour propre;* and do not sufficiently take into account that the matter dealt with consists of conventional decisions, to be adopted for common convenience, but of which the sole value consists in their universal recognition. It is well to draw attention to some of the more important gaps not filled up by the

Paris Committee, especially with regard to the use of words of different meaning in different languages, used however to represent the same thing. To indicate oscillations and undamped waves the term made use of in English is "continuous waves," and in French the non-equivalent "ondes entretenues," while the adjective "persistenti" (persistent) much used by us corresponds neither to the one nor to the other. It would be convenient on the first occasion to come to agreement upon a single adjective which might perhaps be "continuous" (continue). Analogously it would be necessary to choose between "raddrizzatore" ("rectifici," "redresseur") and "rivelatore" ("detector," "detecteur") preferring probably the first. So again for antenna with closed circuit we have translated freely "antenna a telaio" (antenna with frame) against the discordant choice of "coil antenna" in English and of "cadre" (frame) in French. Long discussions took place with regard to the modern systems of "telegraphy and telephony at high frequency" (over wires), because, whilst such denomination was generally accepted, the American representatives manifested their preference for the English expression "line radio," which is not directly translatable and in fact seems not a very happy one because somewhat contradictory in its two terms. Finally, for the frequency, the Committee has, in our judgment inopportunely, left the choice between the expressions in "cycles" ("cicli") or in "periods" ("periodi")—with multiple relations—per second with the corresponding symbols c/s or else p/s.

Dealing with the idea of frequency there was an interesting discussion on the opportunity of substituting for the term to-day so much used of "wavelength" that of "frequency"; and as it was recognised that such substitution is in some cases to be recommended it was decided to publish and to recommend a conversion table for passing from the wavelength in metres to the frequency in thousand-cycles per second (Table I.) [not reproduced].

From what precedes it easily appears that in the field of nomenclature and in that not less important of the choice of symbols and of schematic representations, the work of the Paris Committee has been only a partial and preliminary work, and that it is extremely desirable that it be resumed and completed in the near future.

CLASSIFICATION OF WAVES—EQUIVALENT DECREMENT—INTERFERENCE.

The problem of classification comes into account with regard to the necessary distribution of the different frequencies (wavelengths) and of the diverse types of transmission for different services (movable, fixed, military, special). Attempts at a single classification, that should take account at once of the nature of the waves and of their power of interference showed themselves to be vain and it was agreed to make a double classification, taking account separately of the two criteria.

The classification according to the nature of the waves has led to the definition of two types A and B, of which the first is subdivided into three sub-types A_1, A_2, A_3. The definitions proposed are the following:—

Type A. Continuous Waves.—Waves that in the permanent state are periodic, as well as such that their successive oscillations are identical.

Type A_1. Manipulated Continuous Waves.—Continuous waves of which the amplitude or the frequency vary under the action of a telegraphic manipulation.

Type A_2. Continuous Waves tuned to Audible Frequency.—Continuous waves of which the amplitude or the frequency vary according to a periodic law of audible frequency.

Type A_3. Continuous Waves modulated by Speech.—Continuous waves of which the amplitude or the frequency vary according to the characteristic vibrations of the spoken word (radiotelephony).

Type B. Damped Waves.—Waves composed of successive trains in which the amplitude of the oscillations after having reached a maximum decreases gradually. These definitions are completely independent of the type of apparatus used for producing the oscillations; they do not exclude, for example, from type A_1 the emissions produced by spark apparatus that may be capable of generating true continuous waves, nor from type A_2 the emissions of other spark apparatus capable of generating true continuous modulated waves. The classification proposed has not the pretension of being perfect or definitive, it is easy to see that there may be found some difficulty in including within it some special types (*e.g.*, bi-modulated waves with a modulation of frequency beyond audibility). However the types proposed offer in general a means simple and clear for giving information on the nature of the waves and permit also of defining ultimately the character of an emission, by having recourse to a breaking up of the sub-types according to the rapidity of manipulation, the use of stationary waves, the manipulation or modulation upon amplitude or upon frequency, etc.

The adoption of the criterion relative to the "power of interference" has led to another distinct classification, based on the definition of a conventional magnitude to which is given the name of *equivalent decrement*. This in its turn is defined according to the so-called *resonance curve*. It is known that if there is placed in presence of a circuit traversed by an oscillatory current another resonating circuit (containing capacity and self-induction and in which the causes of loss of energy are reduced to a minimum) and if the frequency proper to this last is made to vary, it is possible to plot as a function of such frequency a diagram of the squares of the induced currents that is called the resonance curve. The shape of this diagram depends it may be on the mode of variation of the primary current, it may be on the total resistance of the resonating or secondary circuit (and besides on the sum of the losses of energy that accompany the passage of the current in the secondary).

The Committee has considered first of all that it may be in general possible to eliminate the influence of the resonating circuit upon the form of the resonance curve, that is that there may be a possibility of rendering negligible the losses in the secondary or of correcting the resonance curve by eliminating the effects of such losses, and has based its definition on such a modified or "corrected" curve of resonance. Besides the Committee has decided that operating during an effective transmission it may be possible to attain a "mean" curve of resonance whose course will be influenced by many of

the causes by which a transmission made nominally upon a certain wavelength (or upon a certain frequency) tends effectively to disturb also the transmissions upon neighbouring wavelengths, occupying thus rather a zone or band of wavelengths than one particular wavelength. Amongst the causes that have influence upon the form of the mean resonance curve it is sufficient to cite the speed of sending and the system of manipulation, the variations of frequency of the generator during a signal, the amplitude and the frequency of modulation, the presence of the wave of compensation, the real decrement, etc.

To pass from the resonance curve to the equivalent decrement it was decided " conventionally " to make use of the following formula :—

$$\delta = \pi \frac{f_1 - f_2}{f_r} \sqrt{\frac{I^2}{I_r^2 - I^2}}$$

As is known this formula is only approximate, and of limited validity even in the theoretical case of purely exponential damping. It corresponds to a curve of resonance symmetrical with respect to the ordinate that passes through the abscissa f_r, to which corresponds the maximum ordinate I_r^2, whilst f_1 and f_2 represent any pair of abscissæ, symmetrical with respect to f_r ($f_1 + f_2 = 2f_r$) for which the ordinate I^2 is the same.

The form of the conventional resonance curve that satisfies the equation adopted for some given values of δ is indicated in Fig. 1.

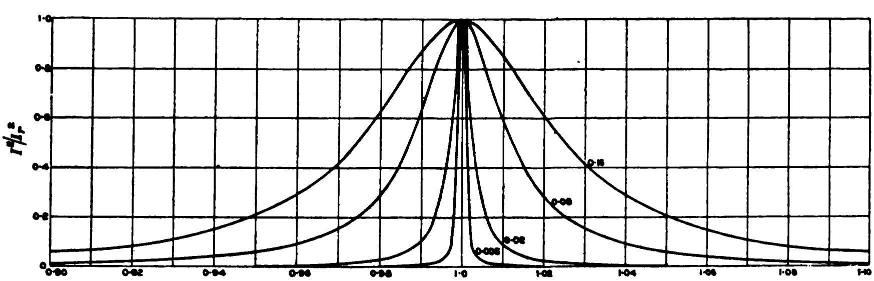

FIG. 1.

If the curve of resonance (mean and corrected for the effects of the losses in the measuring circuit) for a given transmission satisfies the adopted equation, that is, gives rise to a constant value of δ, this would be taken at once as its " equivalent decrement." But in general this will not be the case for the ordinary transmissions and then it is allowed, always conventionally, to assume as the equivalent decrement the maximum value that is able to be obtained from the formula given above, applying it to the resonance curve over a given range. The limits of this range have been fixed, indicating that the value of I^2 must not be greater than $I_r^2/2$ and the frequencies f_1 and f_2 must not be outside the interval from $0{\cdot}9\, f_r$ to $1{\cdot}1\, f_r$. To make precise the application of this rule it is agreed to say that I_r^2 shall be assumed to be the maximum ordinate of the curve of resonance ; but as to f_r it is

not said if this must be assumed to be the abscissa corresponding to such a maximum ordinate, or rather (which is perhaps preferable) the value $\frac{f_1 + f_2}{2}$. In any case the differences owing to this choice can only be very small.

It appears however that the search for the maximum value amongst such as may be calculated from different values of I^2 and from the corresponding pairs of values of f_1 and f_2 in the whole interval indicated, may turn out to be laborious. It would be therefore in our judgment desirable to modify slightly the definition of equivalent decrement, assuming for it a value that will be in general very little superior to that above defined, viz., the decrement that corresponds to the lowest conventional resonance curve that does not fall below the given curve in the whole range delimited by the inequalities * :—

$$I^2 \leqq \frac{1}{2} I_r^2 \qquad f_1 - f_2 \leqq \frac{1}{10} (f_1 + f_2).$$

This last definition is illustrated by Fig. 2. In it the curves 1 and 2 represent two mean resonance curves corrected for the effects of the resonator. The curve 1 is such that the maximum value of δ (equal to 0·0185) is obtained for $I^2 = \frac{1}{2} I_r^2$, as appears from observing that the curve 1 remains for $I^2 < \frac{1}{2} I_r^2$ always below the conventional resonance curve corresponding to $\delta = 0{\cdot}0185$.

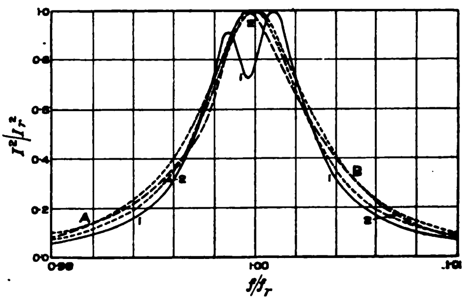

FIG. 2.

On the other hand the curve 2, although giving for $I_r^2 = \frac{1}{2} I_r^2$ a value of δ inferior to that from curve 1, permits of calculating upon lower ordinates values of δ sensibly higher. On examining the figure it is seen that only the conventional resonance curve corresponding to $\delta = 0{\cdot}0205$ (tangent to

* The definition of this range over which the determination of the equivalent decrement is made might perhaps be readjusted, because the ordinates that correspond to the limiting values of the frequencies have magnitudes which differ much according to the value of the decrement. Hence it would appear to be preferable to refer both the limits of the interval to the magnitude of I^2 putting

$$\frac{1}{n} I_r^2 \leqq I^2 \leqq \frac{1}{2} I_r^2$$

and choosing, for example, $n = 100$.

the curve at A and at B) is maintained not lower than curve 2 for $I^2 < \frac{1}{2} I_r^2$. Therefore the equivalent decrement of the first transmission should be 0·0185 and that of the second 0·0205, although rigorously according to the proposals of Paris the decrement of the second might turn out to be a very little lower.*

The determination of the equivalent decrements may be facilitated by distributing upon suitable graphs whole families of conventional resonance curves corresponding to different values of δ. These graphs might be transparent, and in such a case by superposing them on the drawing of the resonance curve for examination, it would be possible to deduce immediately the equivalent decrement. In order to be applicable to every case such curves should be traced by taking for the co-ordinates not indeed the absolute values, but rather the relative values f_1/f_r and I^2/I_r^2, as has been done in the figures. In reducing to these relative scales also the experimental curves obtained from the emissions of which it is desired to determine the equivalent decrement, uncertainty with regard to the choice of the value to be attributed to f_r will present itself, this may be chosen as that corresponding to I_r^2, either as the mean of a determined pair of values f_1 and f_2 corresponding to a given I^2 (*e.g.*, to $I^2 = \frac{1}{2} I_r^2$), or as a mean of these means in a determined interval. In any case the differences that can occur in the results through the effect of such choice are in ordinary cases quite negligible.

It may be deduced from the considerations set forth that a transmission will be characterised within its own type by its mean wavelength (or mean frequency) and by its equivalent decrement. In particular in the case, for example, of an emission of continuous waves, manipulated with a spacing wave, there is no need to indicate the two wavelengths employed, but only a mean wavelength; because the form of the resonance curve and the interference that the transmission may produce is already taken into account in the definition of the equivalent decrement (see, for example, curve 1 of Fig. 2).

The classification adopted to take account of the "power of interference," based on the equivalent decrement, contemplates four distinct classes :—

Class 1. Equivalent decrement comprised between 0·000 and 0·005.
Class 2. Equivalent decrement comprised between 0·005 and 0·02.
Class 3. Equivalent decrement comprised between 0·02 and 0·08.
Class 4. Equivalent decrement comprised between 0·08 and 0·16.

The conventional resonance curves corresponding to the limits between the classes are those traced in Fig. 1.

According to the Paris Committee the classes set apart for the admission

* The coincidence between the value obtained according to the definition proposed at Paris and that deduced according to the variation suggested above would occur only in the case when the two tangential points A and B of Fig. 2 correspond to two equal values of the ordinate.

of each type of emission and of the different series of wavelength (or of frequency) should be those indicated in Table II.

TABLE II.

RELATION BETWEEN THE VARIOUS TYPES AND CLASSES OF W/T WAVES.

Frequencies.	Wavelengths.	Manipulation.	Continuous Wave.		Damped Wave.
			Modulation.	Telephony.	
∞ to 300	0 to 1,000	Class 1	Class 2	Class 3	Class 4
300 to 105·5	1,000 to 2,850	„ 1	„ 2	„ 3	„ 4
105·5 to 37·5	2,850 to 8,000	„ (*) 1 & 2	„ 3	„ 4	„ 4
37·5 to 0	8,000 to ∞	„ 2	(†)	(†)	(†)

The fact should be insisted upon that the classes indicated in the table are only limited classes, but that it is very desirable to extend the traffic depending on the transmission of classes with lower decrement than those indicated: thus, *e.g.*, for the emissions with damped waves (type B) there is in general the possibility of not surpassing class 3, except in the case of signals for help, to which, evidently, any restriction is not applicable. So again in the case of radiotelephony (type A_3) there should be a possibility in the case of the shorter waves of not surpassing class 2.

The conception of "equivalent decrement," introduced and defined in the way indicated permits as is seen of taking account between certain limits of the "power of interference" of a given emission. There are however other causes of interference that can render undesirable certain emissions yet not having an influence on their equivalent decrement. Amongst such causes of interference are specially important:—

(1) The slow variations of frequency (or of wavelength) due, for example, to imperfect regulation of the speed of the electromechanical generators.

(2) The excessive emission of energy upon frequencies different from the frequency of effective transmission (harmonics, etc.).

As regards this the Committee did not consider that it had at present sufficient data for fixing precise rules and has limited itself to recommending to the administrations to establish the maximum limits of tolerance either for the slow variations in frequency, or for the intensity of the electromagnetic field produced at a certain distance from the transmitting antenna and measured at frequencies outside the interval ($0{\cdot}9f_r$ to $1{\cdot}1f_r$), contemplated in the definition of the equivalent decrement.‡

It should be decided also if these limits of the field due to secondary

* In the third line of the third column (type A_1) the class defined is 1 or 2 according as the manipulation is by hand or at high speed.

† For wavelengths above 8,000 m the Committee has resolved that there should be permitted only the emission of type A_1.

‡ If the variation referred to in note (*), p. 22, be accepted the same limits should naturally also be adopted for the measurement of the secondary emissions. Regarding the importance of the harmonics see *L'Elettrotecnica*, 6, p. 716, November 15th, 1919; 8, p. 226, April 5th, 1921; and *Bollettino R.T.*, 1, No. 6, p. 134; 2, No. 14, p. 38.

emissions shall be fixed in absolute value or in relative value with respect to the field produced by the principal emission, also if the distance at which the measurement must be made shall be expressed in kilometres or in wavelengths; in other words it should be decided whether the tolerance with regard to the secondary emissions should be independent or dependent upon the importance of the station. It would seem to us more rational to adopt the second alternative, because at equal distance it appears that there could be tolerated an interference somewhat greater on the part of a large station than of a small one. The Committee recommends that, either the measurements for the determination of the mean resonance curve, or those for the valuation of the field produced by secondary emissions, should be carried out possibly at a certain distance from the antenna, *e.g.*, of the order of a wavelength, with the object of eliminating from the results the effect of casual influences and local perturbations. All this calls for the development of a technique of measurement which is at present in its infancy; and precisely on this account the Committee has expressed the wish that numerous experiments should be carried out in different countries in order to aid the future International Conference in the fixation of the limits of the various rules, indicated only qualitatively up to the present.

(*To be continued.*)

The Amplification of Weak Alternating Currents.*

By H. BARKHAUSEN.

I.—THE ANODE CIRCUIT AND OUTPUT TRANSFORMER.

1. A General Law.

If an apparatus with an impedance $\mathbf{Z}_a$ be inserted in a system (*e.g.*, a circuit containing an A.C. generator) the current will be given by the equation

$$\mathbf{E}_l = \mathbf{I}(\mathbf{Z}_i + \mathbf{Z}_a),$$

where $\mathbf{E}_l$ is the open-circuit voltage, that is the voltage across the apparatus if its resistance were infinitely big or the circuit broken at that point. $\mathbf{Z}_i$ is the internal impedance of the system to an E.M.F. inserted in place of the apparatus. This can be easily determined by a short-circuit test, *i.e.*, by making $\mathbf{Z}_a = 0$, when

$$\mathbf{I}_k = \mathbf{E}_l/\mathbf{Z}_i;$$

it can also be determined in other ways, *e.g.*, by the Wheatstone bridge or by calculation. With alternating currents the magnitudes are vectorial, which is indicated by the symbols in heavy face type.

* Translated from a paper in the *Jahrbuch Zeitschrift für drahtlose Telegraphie.* See Abstract No. 2776 in this issue for references.

The power supplied to the apparatus is

$$P_a = |\boldsymbol{I}|^2 R_a = \left|\frac{\boldsymbol{E_i}}{\boldsymbol{Z_i} + \boldsymbol{Z_a}}\right|^2 R_a$$

where $|\boldsymbol{I}|$ and $|\boldsymbol{E_i}|$ represent the R.M.S. values of the alternating current and voltage. If the resistance of the apparatus be given different values, the power will be a maximum for that value of $\boldsymbol{Z_a}$ which is equal to $\boldsymbol{Z_i}$. *The maximum is not very sharply defined, however, and the exact equality of* $\boldsymbol{Z_a}$ *and* $\boldsymbol{Z_i}$ *is of little importance.* This is shown by the following table and the curve in Fig. 1, wherein the ratio of the maximum power $(P_a)_{\max.}$ to the actual power P_a is given for values of R_i/R_a departing further and further from unity in either direction.

Although the case of non-inductive resistances only has been considered, the relations are very similar in other cases, apart from resonance phenomena. With a telephone one can only just detect a change of 25 per cent. in the current, *i.e.* a 56 per cent. change in the power. This corresponds to an error of 4 : 1 in the

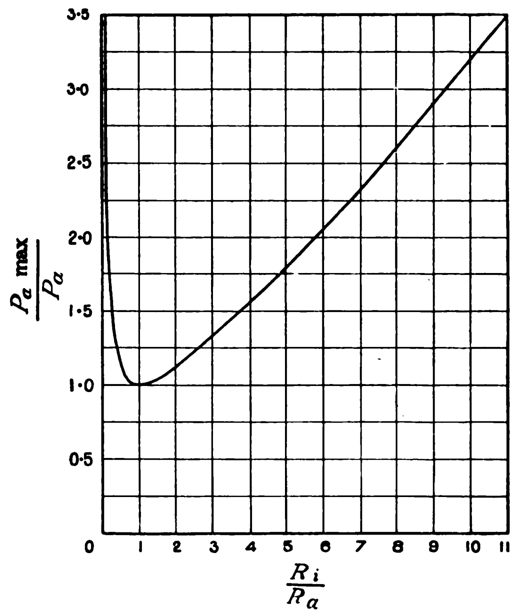

FIG. 1.

TABLE I.

R_i/R_a	$\frac{(P_a)_{\max.}}{P_a} = \frac{(1 + R_i/R_a)^2}{4R_i/R_a}$.
1	1
1·5 or 2/3	1·04
2 ,, 1/2	1·12
3 ,, 1/3	1·33
4 ,, 1/4	1·56
6 ,, 1/6	2·04
10 ,, 1/10	3·2
20 ,, 1/20	5·5
40 ,, 1/40	10·5
100 ,, 1/100	25·5
1000 ,, 1/1000	250

adjustment of R_a and R_i. It is only when R_a and R_i are of a very different order that much is to be gained by adjusting R_a nearer to its ideal value.

2. Power Supplied in the Anode Circuit.

(a) Circuits.

A three-electrode tube, to the grid of which an alternating P.D. of V_g volts is applied, acts in so far as the anode circuit is concerned as a generator of E.M.F. $E = \mu V_g$ with an internal resistance of $R_i = \mu/S$. S is the slope of the characteristic and μ the voltage ratio, *i.e.* $S = \partial I_a/\partial V_g$ and $\mu = -\partial V_a/\partial V_g$. R_i is entirely real, its value being about 100,000 ohms in normal single-grid tubes and about ten times greater or ten times smaller in double-grid tubes with protective or space-charge grids. These are very high resistances and it is not often possible to make the impedance of the receiving apparatus $\mathbf{Z}_A$ even approach so high a value. The impedance of a telephone, for example, hardly ever exceeds 10,000 ohms; and if the amplifier is to work on a telephone line the line impedance to be put for $\mathbf{Z}_A$ is certainly always less than 1,000 ohms.

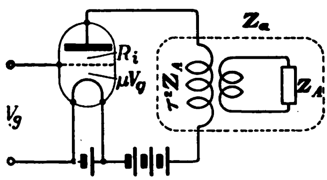

FIG. 2.

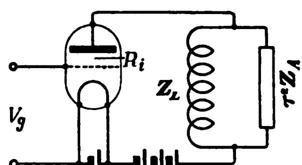

FIG. 3.

In such cases the adaptation can be made by the interposition of a transformer, Fig. 2. The effective primary impedance is then, to a first approximation, equal to $\tau^2\mathbf{Z}_A$, τ being the ratio of transformation which, in a transformer without leakage, is the ratio of the primary to the secondary turns. To a second approximation the magnetising current of the transformer must be included; the effect of this is to put in parallel with $\tau^2\mathbf{Z}_A$ the no-load impedance of the primary winding $\mathbf{Z}_L = R_i + j\omega L$, as in Fig. 3. This again reduces the effective impedance $\mathbf{Z}_a$ and can certainly not be disregarded. Since, in any case, the transformer introduces losses, adaptation by means of a transformer is only suitable when R_i and $\mathbf{Z}_A$ are more than six times each other. (See Table I.)

In apparatus having a high reactance ωL and low ohmic resistance R, the effective external impedance $\mathbf{Z}_a$ can be substantially increased, even without a transformer, by connecting a condenser in parallel with it, as shown in Fig. 4.

The value of $\mathbf{Z}_a$ is then

$$\mathbf{Z}_a = \frac{\mathbf{Z}_L\mathbf{Z}_C}{\mathbf{Z}_L + \mathbf{Z}_C} \doteq \frac{L/C}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$$

which, as shown in Fig. 5, depends on the frequency ω and increases at resonance to $Z_a = L/CR = \omega L\pi/d$ since $\omega L = 1/\omega C$; that is to π/d times its value without a condenser, the increase being for example 6·28 times when the logarithmic decrement $d = 0{\cdot}5$. The ratio of the alternating currents I_L and I_a alters in the same manner as Z_a; at resonance the current in the apparatus I_L is π/d times as great as the anode current I_a (current resonance). This increase in I_L will, however, only be obtained when I_a is

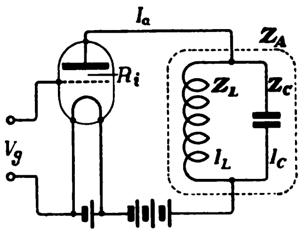

Fig. 4.

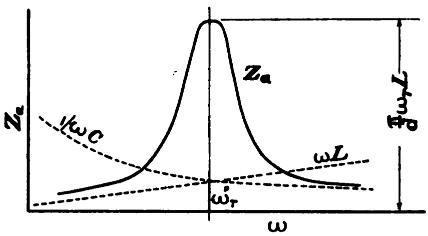

Fig. 5.

not altered by the parallel connection of the condenser, *i.e.*, when Z_a is small compared to R_i. If, on the other hand, Z_a is large compared with R_i, the resonant circuit diminishes the current I_a about d/π times, so that the current I_L in the apparatus remains the same as before. Intermediate cases are easy to follow; for example, consider the favourable case of exact resonance when $Z_a = R_i$; the current amplification of I_L is $\pi/2d$ times, thus only half as great. The increase, that is, the resulting resonance peak is so much greater the larger R_i is compared with Z_a. With small values of Z_a, a fixed frequency is therefore a particular advantage; with large values of Z_a one is tolerably independent of frequency.

Naturally when a transformer is connected to inductive apparatus the inductive current including the magnetising current of the transformer can be compensated by connecting a condenser on the primary or the secondary side. When on the primary side a condenser of τ^2 times the size is required; sharp resonance is only obtained when $\tau^2 Z_A$ is small compared with R_i.

A transformer is often necessary in order to protect the receiving apparatus from the direct current or the high anode potential. This can also be secured—as pointed out by Seibt—by connecting one or two condensers C in series with Z_A and a choking coil, L, in parallel with both (Fig. 6). If Z_A be nearly inductionless and equal to R_A the resonant impedance $Z_a = L/C(R_A + R_L)$ will be essentially greater than R_A with slight damping. By means of current resonance the current in R_A is increased in this case also.

The direct current pressure drop $I_a R_a$ can generally be neglected since I_a is usually less than 1 milliampere. Otherwise it can be allowed for by a suitable increase of the anode battery, in order that the most favourable working point on the characteristic may be reached.

If a weak direct current impulse is to be amplified, as for example a small

voltage V_g, transformers and resonance cannot be employed; the receiving apparatus (relay) must thus be directly connected. The steady current can be prevented from flowing through the relay by means of a sort of compensating arrangement, as shown in Fig. 7. The additional voltage E_z can easily be regulated by means of a potential divider so that the current in the apparatus, I_A, becomes exactly zero. The value of E_z then exactly equals the pressure drop IR. When the resistance R is great compared with R_A the effect of a small change in the grid potential V_g is to produce an alteration in I_a which is followed by a strong positive or negative current I_A, I remaining unaltered. In the particular case when $R_A = R_i$, R must be made large compared with R_i; the pressure drop $E_z = IR$ is therefore not inconsiderable and the anode battery must be increased by this amount in order that the working point remains upon the steep part of the characteristic. R_A can very seldom be made so large as R_i (say 100,000 ohms), so that R and E_z remain small.*

(*b*) *The Anode Efficiency.*

A complete utilisation in the receiving apparatus of the maximum power $(P_a)_{max.}$ which the tube can deliver will seldom be attained in practice. It is seldom possible to obtain a sufficiently high resistance in the receiving apparatus itself. At the best a transformer has not a particularly good efficiency, since it must be kept very small as regard size and cost, and since thin wires must be used on account of the great number of turns required,

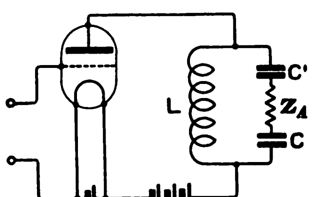

FIG. 6.

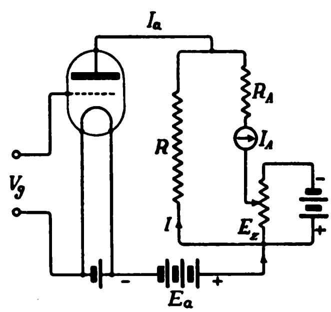

FIG. 7.

a considerable amount of the winding space being already taken up by insulation. In this connection methods of calculation and of measurement are still very backward. The most favourable adjustment of the resistances will be sought for by trial and error with existing apparatus, and is, therefore, not always found. Let the ratio of the effective power P_a used

* The connections are of particular importance for the audion receiver with relay operation. In this case owing to the rectifying action the mean grid pressure will alter and therewith the anode direct current I_a. Details follow later.

in the receiving apparatus to the maximum power $(P_a)_{max.}$ obtainable from the tube be described as the efficiency η_a of the anode circuit, then

$$\eta_a = \frac{P_a}{(P_a)_{max.}}$$

which will seldom exceed 60 per cent. If the receiving apparatus is strongly inductive and resonance is not possible, because of the great range of frequency to be amplified—as in the case of telephonic currents—the efficiency will fall still lower.

Particularly great difficulties arise with high frequencies. Here the capacity of the anode and its leads forms a shunt to $\mathbf{Z}_A$ which cannot be neglected (in Fig. 8 this effective capacity C is shown by dotted lines); C is of the order of about 10 cm. It follows that with 10^6 cycles per second (λ = 300 metres) the value of $1/\omega C$ is only 14,000 ohms. With R_i = 100,000 ohms the alternating anode potential difference is thereby reduced to $\frac{1}{8}$ of the generated E.M.F., so that an anode efficiency of perhaps 30 per cent. can be maintained. This may perhaps be improved by resonant tuning of C by $\mathbf{Z}_A$ or by a separately connected coil, by means of which the resistance, as seen from Fig. 5, will be increased π/d times, but only for the resonant frequency. Or an improvement may be made by the use of tubes with low internal resistance R_i, particularly double-grid tubes with space-charge grids. For greater wavelengths the conditions are more favourable.

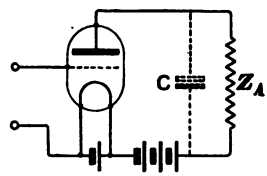

Fig. 8.

Considerably greater difficulties are encountered in dealing with the grid connections. These will be discussed in the next section.

(*To be continued.*)

The Coming of Age of Long-distance Wireless Telegraphy and Some of its Scientific Problems.*

By Professor J. A. FLEMING, F.R.S.

Dr. Fleming began his lecture by reminding his audience that it was just twenty-one years since Senator Marconi began to equip with wireless apparatus a station at Poldhu in Cornwall for the first attempt at transatlantic wireless telegraphy. Up till then only appliances of a laboratory type had been used to signal to distances of about 100 miles. This first attempt at long-distance working necessitated the conversion of these appliances into engineering plant, employing large power. The lecturer described in outline and with the aid of lantern slides the gradual development of high-power wireless stations and of the plant used in them. Dr. Fleming described with the aid of diagrams the general principles of the timed spark, arc, and thermionic valve continuous wave generators and their relative advantages and gave details of some of the recently projected gigantic wireless stations, such as those at St. Assise near Paris and Long Island, U.S.A., in which the high-frequency alternators of Bethenod, Latour, and of Alexanderson are to be employed. He also showed photographs of the first Imperial Wireless Station at Leafield, Oxfordshire, erected by the General Post Office to correspond with one at Cairo. He mentioned recent important installations of large valve

* Abstract of Fifth Henry Trueman Wood Lecture given at the Royal Society of Arts on Wednesday, November 23rd, 1921.

transmitters made by Marconi's Wireless Telegraph Company at Clifden, Ireland, and at their great Carnarvon station in North Wales.

After a discussion of the mode of propagation of E.M. waves, Dr. Fleming proceeded to explain that the presence of the highly conducting layer in the upper regions of the atmosphere, in which the component gases are hydrogen and helium, is probably due to electrified dust which comes to us from the sun, from which it is repelled by the radiation pressure against the gravitation attraction. He said that this dust came from the sun with enormous velocity and entered the higher levels of the atmosphere and rendered it conducting. This conducting layer guides the radio waves round the earth and prevents them from escaping into space.

The lecture concluded with some remarks on the effect of recent physico-mathematical speculations on relativity and especially the agnostic view now taken as regards the existence of a space-filling æther, on the theory of wireless telegraphy. It is clear that space is not a mere vacuum but has remarkable powers of storing and transmitting energy, but modern physical and astronomical discoveries have rendered necessary great modification in our ideas regarding the structure of space or the æther and no theory of radiation has yet been propounded which satisfactorily explains all the known facts.

On the Use of Anderson's Bridge for the Measurement of the Variations of the Capacity and Effective Resistance of a Condenser with Frequency,

and

Notes on Earth Capacity Effects in Alternating Current Bridges.*

By S. BUTTERWORTH, M.Sc.

An analysis of the effect of residuals and earth capacities in Anderson's inductance-capacity bridge was made, and it was shown that if balances are obtained

(*a*) By balancing the bridge with *direct* currents ;

(*b*) By making the alternating current adjustments by means of a small series resistance (s') and parallel condenser (C') in the condenser arm ;

then the changes required in s' and C' to hold the balance at different frequencies are equal and opposite to the variations of the effective (series) resistance and capacity of the condenser with frequency.

The assumptions made in obtaining the above conclusions were that the residual inductances and resistances of the " non-inductive " arms of the bridge are invariable with frequency and that the resistance of the inductive arm varies as the square of the frequency. No knowledge of the absolute values of the residuals, etc., is required for the method.

The method was illustrated by results obtained with a condenser of capacity $0{\cdot}5\mu F$, and details were given showing how the chief experimental trouble, viz., drift in D.C. balance owing to temperature variations, could be overcome.

In the second paper it was shown that an earth capacity acting at any point in the arm of a bridge may be replaced by two earth-impedances acting at the ends of the arm together with an impedance in series with the arm. By integration the result was extended to small distributed capacities.

Two methods were given for the elimination of the error due to the end impedances. Complete elimination can only be obtained by the use of shields connected to the ends of the bridge arm.

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* Abstract of papers read before the Physical Society of London, on Friday, October 28th, 1921.

An Investigation of Transmitting Aerial Resistances.*

By T. L. ECKERSLEY, B.A., B.Sc.

The paper describes an attempt that has been made in the course of some experiments carried out by engineers of Marconi's Wireless Telegraph Co., Ltd., to reduce to a minimum the energy losses in the neighbourhood of transmitting aerials. The efficiency of transmitting aerials may be increased in either one or two ways :—(1) Increase of the height at the expense of very costly towers. These at present are not practical above 800 feet ; and (2) reduction of the dead losses in the surrounding earth and wires so that they shall be small compared with the radiated energy. The second aspect of the question is the one dealt with in this paper.

For the first experiments, which were carried out at Broomfield in July, 1919, an inverted L type of aerial was used and a screen of wires parallel to the horizontal part of the aerial and insulated from the ground was employed as a balancing capacity. This balancing capacity acts as an earth screen to intercept the lines of force from the aerial to earth and to carry the return current through the screen wires rather than through the earth.

According to Maxwell's formula, an earth screen with wires 1 foot apart and 2 feet 6 inches above the ground will, if insulated, carry practically the whole current, less than $\frac{1}{10000}$ per cent. of the total current flowing through the earth.

The screen was accordingly designed on this basis and consisted of 64 wires 1 foot apart and 200 feet long supported on wooden posts at a height of 2 feet 6 inches from the ground. It covered all the space below the aerial and extended in all directions an amount at least equal to the height of the aerial (that is 15 feet) beyond the latter.

It was found by experiment that when the screen was placed in other positions than under the aerial, so that it did not shield the earth from the lines of force, the resistance of the aerial was much larger than when the screen was in its normal position.

The action of the screened aerial from whatever point of view it is regarded can be summarised as follows :—

(1) The losses in the earth are produced by the agency of the horizontal electric force which, in its turn, is produced by the differential action of the horizontal currents in the aerial and screen.

(2) Since there is necessarily a downward radiation from any aerial with horizontal wires, the loss in the earth cannot be completely eliminated except when the conductivity of the earth is perfect, or when there is a perfect reflector between the screen and earth.

(3) The leakage electric force perpendicular to the surface of the earth and calculated on the quasi-stationary theory will contribute to any loss due to the presence of bad dielectrics at the surface of the earth.

Of the experimental results perhaps the most striking from the practical point of view is the reduction of the resistance of the screened aerial as compared with that of the earthed aerial. In the case of the particular aerial on which the measurements were made a fourfold reduction of resistance was found on all wavelengths from the natural wavelength of the aerial to about four times this wavelength. Thus with a screened aerial only a quarter of the power is required in order to obtain a given aerial current and signalling range, or if a definite power supply is available the screened aerial is equivalent to an earthed aerial of double the height.

The "added resistance" method of measuring the high-frequency resistances of the various aerial arrangements was the one adopted, the chief novelty being in the methods of obtaining the relative values of the currents before and after the insertion of the extra resistance. The relative voltages across the aerial loading inductance were the quantities actually measured to give the ratios of the current, the method used being that described in the Radio Review, pp. 303—307, June, 1921. It was found that an accuracy of at least 5 per cent. could be obtained in these measurements. The total resistance of the aerial circuit is made up of the radiation resistance, the ohmic resistance of the wires, the eddy current resistance, dielectric

* Abstract of paper read before the Wireless Section of the Institution of Electrical Engineers, on December 7th, 1921.

losses and leakage losses. A short mathematical analysis of the variations of these losses with the wavelength was given in the paper, together with the results of a series of experiments designed to confirm the theoretical results.

In order to set a limit to the number of screened wires necessary in any given case each of the 64 wires above mentioned was brought to a separate terminal so that any combination of wires could be used. It was found that if the wires were sufficiently few and far between the resistance was inversely proportional to the number of wires but that when they were crowded together so that the distance between them was less than their height above the ground, an increase in the number of wires did not appreciably reduce the resistance of the aerial circuit. A theory explaining this effect is worked out in the paper but the numerical values obtained by its use are about eight times the actual observed one, the discrepancy being due to the neglect of the currents in the aerial wires which acting in the opposite direction to those in the screen wires reduce the electric and magnetic force at the surface of the earth (and consequently the losses) about eight-fold. Further formulæ are also given for the theory of the earth loss taking the above effect into account.

Experiments were also carried out with a radial type of aerial consisting of eight 4-wire sausages radiating from a central 70 foot mast to eight similar masts equally spaced in a 200 foot circle, together with a radial form of earth screen of eighty-eight wires 4 feet 6 inches above the ground arranged like the spokes of a wheel. With this aerial numerous resistance curves were obtained and analysed into their component parts and it was found that the earth loss remained remarkably constant so long as the disposition and height of the wires in the screen were unaltered. Even when the aerial was lowered to half its original height no appreciable change was produced.

This might at first sight appear to contradict the theory given in the paper which attributes the earth loss to a differential effect between the aerial and earth, but it can be shown that so long as the screen effectively shields the earth from the aerial the loss is hardly affected by varying the distribution and height of the aerial wires.

The results of experiments to determine the magnitude of other losses such as leakage and surface dielectric losses are also given but it is pointed out that by careful design most of these can be eliminated.

The discussion of the screened aerial is not complete without mention of some curious effects which were first observed in circular types of aerials, and later in inverted L and T aerials. The effects first showed up as a very rapid increase in resistance at wavelengths close to the natural wavelength of the aerial, an increase which was much too rapid to be accounted for by any change in the eddy currents or radiation resistance. It was later discovered that at still lower wavelengths the resistance decreased again. The resistance curve, therefore, showed a peak in the neighbourhood of some wavelength near the natural wavelength of the aerial. It was natural to suppose that this peak was due to the presence of some oscillation of that particular period, and a short search resulted in the identification of this with the wires of the screen which have, for an end-to-end oscillation, a natural period of this amount.

One method of removing the losses due to the oscillations in the screen is to earth the point on the screen to which the aerial connection is joined. This method has been found fairly effective, but it does not reduce the resistance of the aerial circuit to its normal value in the neighbourhood of the natural period of oscillation of the screen wires. It has also two disadvantages which may in certain cases be serious—(*a*) it introduces the possibility of still another oscillation between the screen and the earth; and (*b*) the point on the screen to which the aerial connection is made will not in general be a natural node of potential for the oscillations in the aerial circuit and therefore to earth this point will introduce earth currents which it is the function of the earth screen to avoid. In an inverted L type aerial the earthing of this point generally leads to about 50 per cent. increase in the resistance. It has, however, been discovered that a point on the loading coil can be found which can be earthed without increasing the resistance.

This is a point of great practical importance as it enables the potentials of the whole system to be stabilised by earthing a definite point.

The currents carried by the wires of the screen should all be equal as oscillations in the screen are liable to occur if the length of the outer wires differs largely from that of the centre wires as in the case of a short broad screen. Again if the aerial is narrow and placed centrally over the middle of the screen it will tend to produce oscillating currents in the screen wires. Losses

due to this cause can be partly avoided by strapping together the ends of the screen wires, but this practice may introduce extra losses in the form of circulating currents round the closed circuits formed by these connecting wires.

The questions raised by the investigation have a very general bearing on wireless practice. We may, in fact, ask ourselves how far we may go on reducing the losses. The very favourable results so far obtained seem to augur a possibility of obtaining even better results in the future. There is still considerable room for improvement, for the earth losses in the cases already investigated still form a large proportion of the total resistance.

The lines along which further reduction in earth loss may be effected are indicated by the theory, which shows that a simultaneous broadening of the screen and aerial have the desired effect. Again, the dielectric loss may be reduced by spacing the wires more and more closely or by using a complete radial screen in which the edge effect is reduced to a minimum.

Screens have been employed successfully at large power stations, for example, at Clifden, and it now requires only one-sixth of the power to produce signals at Glace Bay equal to those formerly produced by the spark station. It is evident, therefore, that the practice of long-distance wireless telegraphy may be very considerably modified by these results.

Obviously, if perfect radiation efficiency can be obtained, the height, size and shape of the aerial will not matter so long as it radiates in the direction required; for all the power put into the aerial is usefully employed in radiation. But when a small or low aerial is used we are likely to experience other troubles. If, for instance, we halve the effective height we must double the current to produce the same range; in fact the currents required are inversely proportional to the heights. For this reason the currents with a low aerial tend to become excessive, and before long the voltage limit of the aerial may be reached. Take the same example again; if we halve the height we must double the capacity for the same maximum voltage in each case, and so on; lowering the aerial to half the height will in most cases hardly increase the capacity, so we shall have to spread the aerial to attain these results.

It is desirable to consider whether the resistance can be reduced in any other manner. Naturally the Alexanderson multiple-earth antenna suggests itself, and perhaps a rough comparison would not be out of place in this paper. By putting the earth losses in parallel, so to speak, instead of in series, the resistance is reduced in the ratio of $n^2 : 1$, where n is the number of earths; but this is emphatically not the case with the dielectric loss, which is left unaltered by this method of earthing and, as we have seen, forms the major portion of the loss on wavelengths which are long compared with the natural wavelength of the aerial.

Any reduction of the surface dielectric loss can be made only by suitably screening the earth. Of course, a combination of the two systems may be used and may in certain cases be preferable, as for example in the case of long, narrow aerials; the multiple-earthed aerial suffers, however, from the disadvantage that it cannot be allowed to oscillate freely, since it has so many possible natural periods, but must be forced to respond to a machine or apparatus of definite frequency which cannot be easily reacted upon.

There is, however, no doubt that in the case of certain existing aerials it is preferable to reduce the resistance by the Alexanderson method. This is especially so in the case of long, narrow aerials. The screening of such an aerial may not reduce the resistance sufficiently and it is a matter of great practical difficulty to widen an existing aerial and reduce the resistance in this way. The only alternative is to make use of Alexanderson feeders and to put the various sections of the aerial in parallel instead of in series, which is, in effect, equivalent to a simultaneous widening and shortening of the aerial. But to get the best results from this method a suitably designed screen should be used to intercept the lines of force from the aerial and to reduce, consequently, the surface dielectric loss.

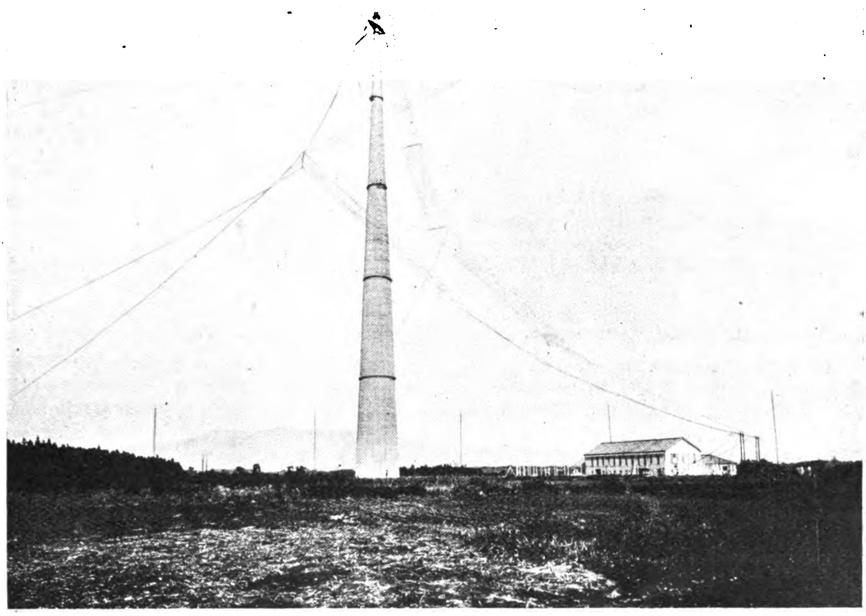
In conclusion, whatever the drawbacks of the screened aerial may be, it is certainly one degree nearer the ideal of perfect radiation efficiency.

Reinforced Concrete Towers for Wireless Stations.

We have received from the Radio Section of the Electrotechnical Laboratory, Japan, a few notes about the high-power radio station at Qwaki, near Tokyo, which was opened in March, 1921. The transmitting and receiving houses are about twenty miles apart, and the former contains arc and H.F. alternator apparatus of 400 kW capacity. The aerial, which is of the

umbrella type, is supported by one main tower 200 metres high, which, as may be seen from the accompanying photograph, is a self-supporting reinforced concrete structure weighing about 11,000 tons. This tower is surrounded by eighteen masts 60 metres high which are arranged in a circle round the central tower.

The station is employed for duplex transmission, with the Hawaiian stations of the Radio Corporation of America, but it is intended to utilise it later for direct European traffic.



Reinforced Concrete Tower to support the Umbrella Type of Aerial used at the Qwaki Wireless Station, Japan.

Notes.

Personal.

The *Telefunken Zeitung* for September, 1921, contains a biographical sketch and portrait of **W. Schlömilch,** who has just completed twenty years' service with the Telefunken Company. [3145]

Oskar Lorenz, a chief engineer of the Telefunken Company, with which he had been connected for twenty-one years, died suddenly on September 15th. The current number of the *Telefunken Zeitung* contains a description of the Königswusterhausen Station from his pen. [4427]

Mr. G. C. Mason, formerly Assistant Wireless Superintendent in the office of the Secretary of the General Post Office, has been appointed Wireless Superintendent in that office. [4491]

Legislation.

WIRELESS TELEGRAPH REGULATIONS IN AUSTRALIA.—Certain changes have been made in the regulations governing the use of Wireless Telegraph Apparatus in Australia by the autho-

rity of the Governor-General acting on the advice of the Federal Executive Council, under date of September 14th, 1921, as set out below :—

The Navigation (Wireless Telegraphy) Regulations, 1921, are amended as follows :—

(*a*) By inserting at the end of paragraph (*b*) of sub-regulation (1) of regulation 13 the following proviso :

" Provided that, where it is shown to the satisfaction of the Director of Navigation that a sufficiency of operators holding First or Second Class Certificates of Proficiency issued by the Postmaster-General and having at least one year's experience as an operator are not available in the Commonwealth, he may to the extent of the deficiency in numbers of such operators, by writing under his hand, permit of the employment, as Second Grade Operators, of persons holding First or Second Class Certificates of Proficiency but with less than one year's experience as operators, and such persons so employed shall be deemed to be Second Grade Operators for the purposes of these Regulations ; " and

(*b*) By inserting at the end of the Schedule thereto the following proviso :—

" Provided that, until otherwise prescribed, the times of watch for operators on Australian trade and limited coast-trade ships to which these Regulations apply may, in lieu of those set out in the Schedule, and at the option of the owner, be in accordance with the provisions of the agreement between the Commonwealth Steamship Owners' Association and others, of the one part, and the Radio-Telegraphists' (Marine) Institute of Australasia, of the other part, dated the 29th March, 1920, certified in the Commonwealth Court of Conciliation and Arbitration of 22nd September, 1920." **[4490]**

Commercial and General.

THE RADIO CORPORATION OF AMERICA has purchased the assets of the International Radio Telegraph Company. Details of the transaction were announced on September 3rd by the Westinghouse Electric and Manufacturing Company in a statement reading in part as follows:—

" The Radio Corporation of America has acquired from the International Radio Telegraph Company a group of patents relating to wireless telegraphy which the Radio Corporation found it necessary to make use of to enable it to give the public proper and efficient service.

" The International Company had not embarked upon commercial work to any great extent and was confronted with important patents owned by the Radio Corporation, so that neither Company was able to give to the public satisfactory service without infringing upon the patents of the other. Under the circumstances it was found essential that the right to use the several groups of patents should be acquired by one corporation."

The purchase was made, it is understood, with 1,000,000 shares of $5 par value preferred and 1,000,000 shares of no par value common stock of the Radio Corporation. Under this arrangement it is understood that there will be a pooling of all radio patents owned by the Westinghouse Electric and Manufacturing Co., the International Radio Telegraph Co., the American Telephone and Telegraph Co., the American General Electric Co., the American Marconi Company, and the Radio Corporation of America. **[4162]**

AN APPLICATION BY THE INTER-CITY RADIO COMPANY of New York for an injunction to restrain the Department of Commerce, U.S.A., from revoking its licence to use wireless installations has been withdrawn and a satisfactory settlement made between the Company and the Department of Commerce. This agreement permits the Radio Company to operate its wireless business in New York, Cleveland, Detroit and Chicago. **[4188]**

NEW WIRELESS STATION.—A large wireless station has been erected near Moscow to enable communication to be made with all other countries. **[4158]**

WIRELESS IN RUSSIA.—The wireless network in Russia is covered by 597 wireless stations —about six times as many as in the British Isles. These provide efficient communication between Siberia and all other parts of the country including Turkestan. **[4159]**

WIRELESS IN MAURITIUS.—According to *The Times Trade Supplement* the Imperial Authorities have decided to discontinue the working of the wireless station erected at Rose Belle in Mauritius during the war. As the result of representations by the commercial community it is possible that this decision may be reconsidered provided that the local Government will assume financial responsibility for the station. **[4064]**

Review of Radio Literature.

1. Abstracts of Articles and Patents.

(F.) Thermionic Valves, and Valve Apparatus.

2776. **H. Barkhausen.** The Three-electrode Valve and its Technical Applications.—II. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 82—114, August, 1920. *Radioélectricité*, 1, p. 103D, March, 1921.) For Part I. see *Jahrbuch*, 14, pp. 27—47.

A very thorough discussion of the application of the valve to the amplification of weak alternating currents. See pp. 25—30 in this issue for fuller abstract.

2777. **Siemens Schuckertwerke.** Electrodes for Electric Discharge Apparatus. (*British Patent* 144295, June 2nd, 1920. Convention date June 4th, 1918.

Refers to the construction of a water-cooled electrode for thermionic valves.

2778. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Valves. (*British Patent* 150359, August 1st, 1916. Patent accepted September 9th, 1920.)

An addition to *British Patent* 15555/1915. A thermionic valve of the dynatron type is provided with an additional control electrode or grid.

2779. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Electric Relays. (*British Patent* 154232, February 22nd, 1916. Patent accepted December 2nd, 1920.)

An amplifier consisting of a thermionic valve arranged as a negative resistance in parallel with an ordinary resistance.

2780. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Relay. (*French Patent* 512139, April 10th, 1919. Published January 15th, 1921.)

The valve tube has a third electrode arranged so that for a certain range of electric pressure the current between the cathode and the third electrode varies oppositely to the pressure. See also *British Patent* 15555/1915, and Abstract 2778 above.

(G.) Transmitter Control or Modulation.

(1) GENERAL ARTICLES OR METHODS.

2781. **W. Noble.** The Long Distance Telephone Systems of the United Kingdom. (*Journal of the Institution of Electrical Engineers*, 59, pp. 389—426, April, 1921. *Electrician*, 86, pp. 350—352, March 25th; pp. 376—378, April 1st, 1921. *Technical Review*, 9, p. 79, May 3rd, 1921. *Electrical World*, 77, p. 1175, May 21st, 1921—Abstract.)

Includes descriptions of valve repeating and amplifying apparatus.

2782. **J. Scott-Taggart.** The Vacuum Tube in Radiotelephony. (*Radio News*, 2, pp. 865 and 898—904, June, 1921. *Technical Review*, 7, p. 183, November 9th, 1920—Abstract. *Science Abstracts*, 23B, p. 495, Abstract No. 939, October 31st, 1920—Abstract. *Revue Générale de l'Électricité*, 9, p. 257—259, February 19th, 1921—Abstract. *Radioélectricité*, 1, p. 71D, December, 1920—Abstract.)

This article has already been abstracted from other sources. (RADIO REVIEW Abstract No. 1225, December, 1920.)

2783. **O. Reichenheim.** Apparatus for Wireless Telephony. (*German Patent* 316224, September 3rd, 1915. Patent granted November 22nd, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 385—386, November, 1920.)

A scheme of wireless telephony by means of damped waves of a group frequency different from the mean speech frequency. By means of a system of one or more resonant circuits the note of the spark frequency is prevented from reaching the telephone.

2784. **W. S. Lemmon.** Recent Development of Radio Telephones. (*Q.S.T.*, 3, pp. 7—11, June, 1920.)

2785. **R. V. Hartley.** Prevention of Signal Distortion. (*Wireless Age*, 8, pp. 16—17, June, 1921. *Science Abstracts*, 24B, p. 415, Abstract No. 848, August 31st, 1921—Abstract.)

To remedy the distortion occurring in a wireless telephone transmitter due to partial suppression of the side tones of the carrier waves to which the receiving circuits are not in tune, circuits are proposed for emphasising the amplitude of the higher frequency speech currents.

2786. **R. A. Heising.** Modulation in Radiotelephony. (*Q.S.T.*, 4, pp. 7—12, July, 1921; 5, pp. 9—15, August, 1921.)

Gives a general discussion of various modulation methods in radiotelephonic transmitters with a view to comparing their relative efficiencies. At the conclusion of the second part tables are given of the best constants for various types of circuit.

2787. **J. Scott-Taggart.** Two Practical Radio Telephone Circuits. (*Radio News*, 2, p. 518, February, 1921.)

2788. **A. S. Blatterman.** Notes on Modulated Tube Transmitters. (*Radio News*, 2, pp. 524—525 and 573—577, February, 1921. *Radioélectricité*, 1, p. 145D, June, 1921—Abstract.)

A discussion of the mode of operation of various modulation circuits with comparisons of their relative merits.

2789. **M. Wolf.** Determination of Percentage Modulation in Radiotelephony. (*Radio News*, 3, pp, 19 and 61—62, July, 1921.)

Describes how the effectiveness of the modulation of a radio telephone transmitter can be determined in any given case.

2790. The Vacuum Tube in Wireless Telephony. (*L'Électricien*, 52, pp. 396—398, September 1st, 1921.)

A brief description of various methods of modulation for wireless telephony using valves.

2791. **J. H. Hammond.** Wireless Signalling. (*British Patent* 166195, September 26th, 1918. Patent accepted September 11th, 1921.)

In a system of wireless signalling the signals are caused to vary the supersonic group frequency of trains of damped waves emitted from a transmitting station, or the beat frequency where continuous waves are employed. The group frequency is changed by means of a commutator or by a hand-operated switch. At the receiving station the incoming signals are rectified and combined with local oscillations for the production of audible beats.

2792. **A. H. Taylor.** Radiotelegraph and Telephone Transmitter and Receiver. (*Wireless Age*, 8, pp. 21—22, July, 1921.)

Describes an arrangement for effecting combined telegraphic and telephonic transmission from a single wireless station and aerial. Circuit diagrams for transmission and reception are given.

2793. **E. G. Velasco.** Problems in Wireless Telephony; The Causes of Speech Distortion. (*Energia Elect.*, pp. 153—154, July 25th, 1921.)

(2) SIGNALLING KEYS AND METHODS.

2794. **Gesellschaft für drahtlose Telegraphie.** Wireless Signalling. (*British Patent* 147429, July 7th, 1920. Convention date July 15th, 1915. Patent accepted August 4th, 1921.)

Methods of controlling the emission of signals in systems in which oscillations are generated by a retro-active thermionic valve. A key when depressed completes the usual grid circuit and in its back position connects the grid to the negative pole of a battery.

2795. **H. J. Round** and **W. T. Ditcham.** Wireless Transmitting Apparatus. (*British Patent* 158291, August 19th, 1919. Patent accepted February 10th, 1921.)

Relates to special keying arrangements in connection with rectifying and transmitting valves.

2796. **Gesellschaft für drahtlose Telegraphie.** Wireless Transmitters. (*British Patent* 147434, July 7th, 1920. Convention date October 20th, 1917. Patent accepted October 7th, 1921.)

A tone transmitter comprising a valve oscillation generator with its grid circuit influenced

by currents of audible frequency, such as may be derived from a buzzer. Alternatively the low frequency tone may be generated by the same valve oscillating at an audible frequency.

2797. **P. Boucherot.** Relays for Wireless Transmitters. (*British Patent* 160730, March 22nd, 1921. Convention date March 24th, 1920. Patent not yet accepted.)

2798. **J. H. Hansen.** Morse Transmitters. (*British Patent* 155162, March 31st, 1920. Patent accepted December 16th, 1920.)

2799. **E. F. Huth.** Wireless Transmitting Apparatus. (*British Patent* 148316, July 9th, 1920. Convention date October 21st, 1914. Patent not yet accepted.)

A Morse writer is actuated by the transmitting key for maintaining a record of the messages sent out.

2800. **W. T. Ditcham.** Wireless Transmitting Apparatus. (*British Patent* 162761, January 31st, 1920. Patent accepted May 2nd, 1921.)

For transmission with an oscillating valve, using an A.C. supply and a rectifying valve to supply the oscillating valve, the key is connected in parallel with a choke or resistance which is inserted in series with the A.C. supply.

2801. **W. T. Ditcham.** Wireless Transmitters. (*British Patent* 162762, January 31st, 1920. Patent accepted May 2nd, 1921.)

In inductively coupled transmitters, the key is arranged to short circuit the coupling coil, which contains a few turns only and is separated from the main inductance of the circuit to which it is connected.

2802. **W. H. Eccles** and **J. H. Vincent.** Wireless Signalling. (*British Patent* 163462, February 17th, 1920. Patent accepted May 17th, 1921.)

Signalling is effected by small changes in the frequency of the waves. At the receiver an indicating circuit is arranged to be influenced both by the incoming signals and by a local heterodyne. The deflections of the indicator show large changes for minute changes of frequency. Modifications are described to render the method applicable to transmission with an arc.

(3) AUTOMATIC AND HIGH SPEED APPARATUS.

2803. **D. A. E. A. Bontekoe.** High-speed Radio Transmitter. (*Radio Nieuws*, 4, pp. 16—21, January, 1921.)

An illustrated account of a transmitter of the Wheatstone type, presumably of Austrian origin.

2804. **W. H. Nottage** and **T. D. Parkin.** Wireless Calling Apparatus. (*British Patent* 161652, January 9th, 1920. Patent accepted April 11th, 1921.)

Relates to a vibrating balance wheel mechanism for automatic calling and for receiving the call. (See also RADIO REVIEW, 1, p. 293, March, 1920.)

2805. **W. Klaus.** The Kleinschmidt Automatic Transmitter. (*Radio News*, 2, p. 283, November, 1920.)

An illustrated description of the working of this perforator and transmitter.

2806. **H. Verch.** High-speed Wireless in Large Stations. (*Telefunken Zeitung*, 4, pp. 17—25, March, 1921.)

A well-illustrated article describing the various transmitting and receiving arrangements for high-speed working, including phonograph and telegraphone.

2807. **F. Banneitz.** Experiments and Tests of High-speed Wireless Telegraphy in the German Post Office. (*Elektrotechnische Zeitschrift*, 42, pp. 714—716, July 7th, 1921—Abstract. *Post Office Electrical Engineers' Journal*, 14, pp. 158—163, October, 1921—Abstract. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 136—137, August, 1921—Abstract.)

The original of this report has already been abstracted. (See RADIO REVIEW Abstract No. 1065, November, 1920.)

2808. Wireless Wheatstone Trials. Aldershot—Cologne. (*Telegraph and Telephone Journal*, 7, pp. 101—102, April, 1921. *Annales des Postes et Telephones*, 10, pp. 553—555, September, 1921.)

A short account of high-speed wireless transmission tests carried out between Aldershot and Cologne using the military wireless station. The trials extended over a period of three days and perfect transmission at 100 words per minute was obtained. Out of a total of 1,053 telegrams 93 per cent. were correctly received. A specimen of the Wheatstone slip taken at 150 words per minute is reproduced.

(4) VALVE MODULATORS.

2809. **P. P. Eckersley.** Wireless Signalling. (*British Patent* 146610, April 10th, 1919. Patent accepted July 12th, 1921. *Engineer*, 130, p. 170, August 13th, 1920—Abstract.)

A "quiescent aerial" type of transmitter in which the grid circuit of the power valve is continuously excited by feeble oscillations of the same frequency generated by an auxiliary valve.

2810. **L. de Forest.** Modulating Apparatus for Radiotelegraphic Transmitters. (*British Patent* 149272, July 14th, 1920. Convention date May 10th, 1915. Patent not yet accepted.)

Describes the use of a three-electrode valve connected in shunt to the antenna circuit of a C.W. transmitter for modulating the radiated output from that circuit. The transmitting microphone is connected to the grid circuit of the shunt modulator valve in series with a battery for giving the grid the necessary negative voltage.

2811. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Wireless Transmitting Arrangements. (*British Patent* 149466, May 28th, 1919. Patent accepted August 19th, 1921.)

For modulating the output of a valve transmitter it is proposed to feed two valves connected in opposite directions from the currents derived from the modulating microphone. The two valves are arranged in opposite directions so that both half-ways of the modulating current are utilised.

2812. **E. F. Huth.** Wireless Modulating Apparatus. (*British Patent* 148801, July 10th, 1920. Convention date April 3rd, 1919. Patent not yet accepted.)

Oscillations produced by a thermionic valve are modulated by means of a shunt of variable impedance across the valve. This shunt may consist of an auxiliary valve having its grid potential controlled by the transmitting microphone.

2813. **S. Loewe.** Wireless Telephony. (*British Patent* 149214, July 12th, 1920. Convention date October 29th, 1918. Patent not yet accepted.)

In thermionic apparatus particularly applicable to wireless telephony the transmitting valve is in parallel with a control valve. The grid circuit of the control valve includes a transformer influenced by telephone currents produced in any suitable way, a condenser telephone in conjunction with an amplifier being mentioned as particularly suitable. The two valves may be combined in one tube having two grids, the control grid being near to the cathode.

2814. **J. B. Bolitho.** Wireless Telephone Apparatus. (*British Patent* 156876, October 6th, 1919. Patent accepted January 20th, 1921.)

For the modulation of oscillations produced by a thermionic valve having a retroactive coupling a control circuit is used containing another three-electrode valve and an inductance coupled with the oscillation circuit in such a way that the reaction in them opposes the retroaction in the generating circuit.

2815. **E. F. Huth Gesellschaft.** Wireless Telephonic Transmitting Apparatus. (*British Patent* 157924, January 10th, 1921. Convention date March 22nd, 1919. Patent not yet accepted.)

A modulating arrangement in which the microphone controls the valve filament temperature.

2816. **M. Latour.** Thermionic Oscillation Generators. (*British Patent* 147757, July 8th, 1920. Convention date August 16th, 1915. Patent not yet accepted.)

Modulation of the C.W. output may be obtained (1) by feeding the plate with A.C.; (2) by introducing a low frequency oscillation circuit in the D.C. supply circuit; (3) by using two oscillation circuits to produce audible frequency beats.

2817. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Modulating Apparatus. (*British Patent* 155602, September 11th, 1918. Patent accepted February 30th, 1920.)

To control the energy supplied from an oscillating valve V_1 to the aerial circuit a modulating valve V_2 is joined up as indicated in Fig. 1.

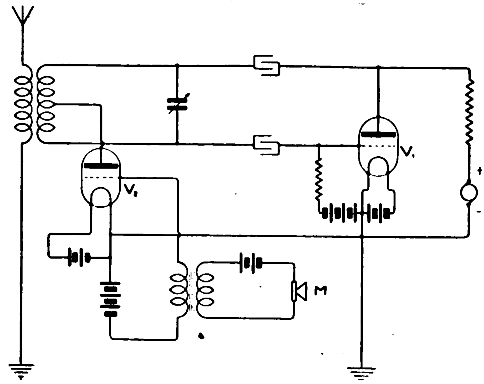


FIG. 1.

2818. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Wireless Signalling Apparatus. (*British Patent* 144803, March 17th, 1919. Patent accepted June 17th, 1920.)

A modification of the shunt valve method of modulation in which the valve is coupled inductively to the transmitting aerial instead of being directly connected to it.

2819. **A. K. Macrorie** and **G. A. Irving.** Wireless Telephony. (*British Patent* 162781, February 3rd, 1920. Patent accepted May 3rd, 1921.)

Relates to a resistance coupled cascade amplifier arranged to amplify the microphone current and to modulate the output of the oscillating valve.

2820. **R. V. L. Hartley** [Western Electric Company]. Valve Modulating Apparatus. (*British Patent* 151928, September 21st, 1920. Convention date September 29th, 1919. Patent not yet accepted.)

An addition to *British Patent* 102503 dealing with two valves arranged for modulating purposes.

2821. **Gesellschaft für drahtlose Telegraphie.** Wireless Telephone Transmitters. (*British Patent* 157407, January 10th, 1921. Convention date December 23rd, 1919. Patent not yet accepted.)

Modulation of a valve generator by means of a valve modulator controlled by a microphone. The valve modulator is connected in parallel with the valve generator plate filament circuit.

2822. **H. Vogt, J. Engl** and **J. Massolle.** Modulation of High-frequency Oscillations. (*British Patent* 157437, January 10th, 1921. Convention date April 7th, 1919. Patent not yet accepted.)

High-frequency oscillations for use as carrier waves are modulated by means of a photo-electric cell having one or more anodes or cathodes in an exhausted chamber. The cathodes are coated with an alkali metal.

2823. **Gesellschaft für drahtlose Telegraphie.** Wireless Signalling. (*British Patent* 154181, October 26th, 1920. Convention date November 11th, 1919. Patent not yet accepted.)

Microphone currents impressed on the grid of a thermionic valve vary its internal resistance. This varying resistance is utilised as a means of varying the amplitude of the oscillations produced by a valve generator by connecting it in series with the anode circuit of the oscillating valve.

2824. **W. T. Ditcham.** Wireless Telephony. (*British Patent* 164105, February 28th, 1920. Patent accepted May 30th, 1921.)

A wireless telephony transmitting arrangement wherein the aerial circuit is influenced by the resultant beat frequency of two superimposed oscillating circuits, one of which is modulated.

2825. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Valves (*French Patent* 509928, December 31st, 1919. Published November 23rd, 1920.)

The specification describes a device for controlling alternating electric currents which consists of a hollow container having one or more main anodes and a vaporisable cathode, such as mercury, with an intermediate electrode or grid, to which is applied a variable negative potential. (See also corresponding *British Patent* 5684/15.)

2826. **J. Scott-Taggart.** A Quiescent Aerial for Wireless Telephony. (*Electrician*, 87, pp. 234—235, August 19th, 1921.)

A description is given of the application of a double grid thermionic valve * for the modulation of a radiotelephone transmitter. One grid is supplied from the source of continuous oscillations, which may be an ordinary oscillating valve and the second grid is connected to the modulating microphone with the application of a sufficiently large negative potential to reduce the normal anode current practically to zero. Normally therefore no radiation takes place but positive impulses on the second grid from the modulating microphone cause radiation to take place.

2827. **W. A. MacDonald.** Radiotelephone Circuits and Modulation. (*Radio Review*, 2, pp. 409—419, August, 1921.)

2828. **Le Matériel Téléphonique.** Continuous Wave Transmitter. (*French Patent* 513761, April 15th, 1920. Published February 23rd, 1921.)

High-frequency oscillations are modulated in accordance with low-frequency signals by impressing both potential variations on the grid circuit of a thermionic valve, the output circuit of which is coupled to the transmitting aerial or a wire conductor. (See also *British Patent* 141732—RADIO REVIEW Abstract No. 891, October, 1920.)

2829. **R. A. Heising.** Control Means for Vacuum Tube Generator. (*Wireless Age*, 8, pp. 19—20, April, 1921.)

Describes various arrangements for microphonically modulating the output of an oscillating valve, and deals in particular with arrangements in which the microphone controls the output by changing the working conditions of the valve into the oscillatory or non-oscillatory state. The microphone circuit may be arranged to provide part of the retroactive coupling of the oscillatory valve.

2830. **S. Brydon** and **A. G. T. Cusins.** Wireless Signalling. (*British Patent* 166594, September 27th, 1919. Patent accepted July 11th, 1921.)

As a means of controlling the amplitude of high-frequency oscillations in a valve generator the anode-cathode resistance of one or more control valves is arranged in series with the source of current supply to the anode circuit of the generator. The magnitude of the anode current in the generator is varied by means of the anode-cathode resistance of the control valve or valves by a variation of grid potential.

2831. **E. H. Colpitts** and **H. de F. Arnold** [Western Electric Company]. Radiotelephone Transmitter. (*U.S. Patent* 1388450, September 3rd, 1915. Patent granted August 23rd, 1921.)

High-frequency oscillations of feeble amplitude are generated at the transmitter and these feeble oscillations modulated while in their feeble state. These feeble modulated oscillations are then amplified both in voltage and amperage to sufficient power for effective transmission.

(5) MAGNETIC MODULATORS.

2832. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Controlling Apparatus for Radio Transmitters. (*British Patent* 148758, July 9th, 1920. Convention date October 14th, 1913. Patent not yet accepted.)

In a method of controlling the amplitude or frequency, or both, of the emitted waves, the value of an inductance in the aerial or oscillation circuit, or in both, is varied by the speech currents. The inductance has one or more high-frequency windings and the direct-current windings, one of which is supplied with steady current and the other with speech currents. Transformer action between the high and low-frequency windings is prevented by the method of winding.

2833. **Allgemeine Elektricitats-Gesellschaft.** Inductances. (*British Patent* 149236, July 12th, 1920. Convention date September 17th, 1914. Patent not yet accepted.)

A short circuited winding is provided for the purpose of protecting the windings or the apparatus connected thereto from undesired voltages of double frequency.

2834. **Gesellschaft für drahtlose Telegraphie.** Wireless Signalling. (*British Patent* 147430, July 7th, 1920. Convention date December 24th, 1915. Patent not yet accepted.)

Magnetic modulation of waves generated by a Poulsen arc, by exciting one winding of a

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* See RADIO REVIEW Abstract No. 1987.

cloud iron transformer—with which the arc circuit is coupled to the aerial—by a low-frequency alternator.

2835. **Gesellschaft für drahtlose Telegraphie.** Controlling or Modifying High-frequency Currents. (*British Patent* 157408, January 10th, 1921. Convention date December 27th, 1919. Patent not yet accepted.)

A means of varying the frequency and voltage of the output of a source of alternating current by means of an easily variable inductance controlled by the modulating microphone.

2836. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Wireless Signalling. (*British Patent* 154247, May 27th, 1919. Patent accepted November 29th, 1920.)

In a method of controlling the amplitude of the emitted waves by varying the effective resistance of the aerial circuit without varying its natural frequency, the depression of the signalling key varies the saturation of one or more magnetic amplifiers.*

(6) ELECTROSTATIC MODULATORS.

2837. **J. Massolle, H. Vogt** and **J. Engl.** Wireless Telephone Apparatus. (*British Paten* 157748, January 10th, 1921. Convention date March 3rd, 1919. Patent not yet accepted.)

An oscillating valve is differentially coupled to the output oscillation circuit, and the transfer of energy to this circuit is controlled by a condenser having a flexible armature between two fixed plates. The sound waves directly influence this diaphragm for telephonic transmission.

2838. **E. Waltz** and **H. Meusser.** Reproducing Sounds. (*British Patent* 157942, January 10th, 1921. Convention date December 22nd, 1919. Patent not yet accepted.)

Variations of potential applied to a condenser vary its capacity and hence control the thermionic valves.

(7) SPECIAL MICROPHONE APPARATUS.

2839. **O. Angelini.** Microphone. (*French Patent* 506385, November 19th, 1919. Published August 20th, 1920.)

2840. **L. van Rutten** [Western Electric Company]. Telephone Transmitters. (*British Patent* 144698, June 10th, 1920. Convention date June 22nd, 1914. Patent accepted January 20th, 1921.)

A microphone transmitter of the granular type.

2841. **H. J. Palmer** and **Telephone Manufacturing Company.** Microphones. (*British Patent* 159609, December 2nd, 1919. Patent accepted March 2nd, 1921.)

2842. **B. F. Miessner** [Miessner Inventions Corporation]. Telephone Transmitters. (*British Patent* 146105, June 17th, 1920. Convention date June 23rd, 1919. Patent accepted May 26th, 1921.)

Relates to microphonic transmitters in which the sound is admitted to both sides of the diaphragm to nullify the effects of disturbing sounds.

2843. **A. Thomas.** Microphones. (*British Patent* 154729, September 11th, 1919. Patent accepted December 9th, 1920.)

2844. **J. S. Timmons.** Microphones. (*British Patent* 152761, July 18th, 1919. Patent accepted October 18th, 1920.)

Microphonic apparatus specially adapted to noisy situations.

2845. **E. F. Huth** and **S. Loewe.** Microphones. (*British Patent* 148312, July 9th, 1920. Convention date December 31st, 1915. Patent accepted October 10th, 1921.)

Relates to diaphragmless microphones for use in noisy places.

2846. **E. F. Huth** and **S. Loewe.** Microphones for Wireless Telephony. (*British Patent* 148313, July 9th, 1920. Convention date November 28th, 1916. Patent not yet accepted.)

Deals with the application of diaphragmless microphones as described in the preceding Abstract to wireless telephone transmitters on aircraft.

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* See *British Patent* 7151/13.

2847. **C. H. Pritchard** and **J. Mangles.** Microphone Transmitter. (*British Patent* 156354, October 20th, 1919. Patent accepted January 13th, 1921.)

2848. **C. Kearton** and **G. B. Riley.** Microphones. (*British Patent* 156403, December 19th, 1919. Patent accepted January 13th, 1921.)

2849. **R. L. Murray** [Telephone Manufacturing Company]. Microphones. (*British Patent* 151336, June 18th, 1919. Patent accepted September 20th, 1921.)
Microphones for use in noisy places are fastened to the speaker's throat or neck.

2850. **H. Vogt, J. Engl** and **J. Massolle.** Telephony. (*British Patent* 157442, January 10th, 1921. Convention date August 2nd, 1919. Patent accepted September 22nd, 1921.)
An arrangement whereby the distances between an anode and heated cathode are varied by speech vibrations impressed on a diaphragm which may carry the anode plate, or by other suitable means.

2851. **W. K. L. Dickson.** Microphones. (*British Patent* 154335, August 26th, 1919. Patent accepted November 26th, 1920.)
The capsules of a microphone are of special design and geometrically arranged to ensure a constant number of contacts in operation and to prevent jamming.

2852. Anti-noise Telephone for Motor Ships. (*Technical Review*, 9, p. 186, June 21st, 1921.)
Describes an anti-noise transmitter so constructed as to allow extraneous sound-waves equally free access to both sides of the diaphragm. Being thus, as it were, in sound equilibrium, the diaphragm is free to vibrate solely to the directed sound-waves from the lips of the operator impinging against one side only.

2853. **Signal Gesellschaft m.b.H.** Telephony. (*French Patent* 512573, February 26th, 1916. Published January 26th, 1921.)
The transmitter of a telephone is divided into compartments by a grid formed of plush so arranged that the fibres are all inclined in one direction in relation to the electrodes. To prevent fraying of the edges when cutting, the plush is gummed to a paper back. (For further particulars see *British Patent* 100156.)

(8) TIME SIGNALLING APPARATUS.

2854. **A. Gradenwitz.** Nauen Time Signal Radio Service. (*Radio News*, 3, pp. 12 and 78, July, 1921.)
Illustrated description of the apparatus.

(9) AND (10) RELAYING APPARATUS (WIRE TO RADIO AND RADIO TO RADIO).

2855. Radiophone—Telephone Linking. (*Q.S.T.*, 4, pp. 21—22, November, 1920.)

2856. **Western Electric Company.** Telephone Relaying Systems. (*British Patent* 143949, January 29th, 1919. Patent accepted July 31st, 1920, and 144152, September 2nd, 1919. Patent accepted June 10th, 1920.)
Relates to means for controlling valve relaying apparatus over telephone lines.

2857. **A. B. Clark** [Western Electric Company]. Telephone Receiver. (*British Patent* 144293, June 2nd, 1920. Convention date September 20th, 1918. Patent accepted October 28th, 1920.)

2858. **A. B. Clark** [Western Electric Company]. Telephone Repeaters. (*British Patent* 149331, July 19th, 1920. Convention date July 31st, 1919. Patent accepted September 22nd, 1921.)
Relates to an arrangement of valve telephone repeaters to avoid singing of the repeater when the input and output circuits are unbalanced.

2859. **Western Electric Company.** Telephone Repeating Apparatus. (*British Patent* 149139, September 1st, 1919. Patent accepted August 12th, 1920.)
Relates to thermionic valve repeaters.

2860. **E. A. Graham, W. J. Rickets** and **E. A. Sauftleben.** Telephone Repeaters. (*British Patent* 151118, July 4th, 1919. Patent accepted September 23rd, 1920.)

2861. **Western Electric Company.** Telephone Repeaters and Filters. (*British Patent* 151140 August 5th, 1919. Patent accepted September 23rd, 1920.)

2862. **C. Robinson** and **R. M. Chamney.** Telephone Repeaters. (*British Patent* 145869, April 1st, 1919. Patent accepted July 2nd, 1920.)

Deals with the design of the transformers for valve repeaters.

2863. **R. Fiedler** and **K. Hopfner.** Relaying Apparatus. (*British Patent* 158536. November 23rd, 1920. Convention date February 5th, 1920. Patent not yet accepted.)

Relaying apparatus for coupling wire and wireless circuits or wire to high-frequency wire telephone circuits.

2864. **M. Latour.** Telephone Repeaters. (*British Patent* 147756, July 8th, 1920. Convention date May 23rd, 1919. Patent not yet accepted.)

2865. **M. Latour.** Thermionic Repeaters. (*British Patent* 147759, July 8th, 1920. Convention date June 25th, 1915. Patent not yet accepted.)

Repeater arrangements to reduce the effects of disturbances.

2866. **Western Electric Co.** Repeaters. (*British Patent* 149858, October 3rd, 1919. Patent accepted August 26th, 1920.)

2867. **Siemens and Halske Akt. Gesellschaft.** Telephone Repeaters. (*British Patent* 153301, November 1st, 1920. Convention date October 31st, 1919. Patent not yet accepted.)

2868. **Automatic Telephone Manufacturing Co., Ltd.** and **H. H. Harrison.** High-frequency Electric Signalling Systems. (*British Patent* 157556, October 20th, 1919. Patent accepted January 20th, 1921.)

A repeating arrangement for use in telegraph or telephone stations, a number of carrier waves being employed for transmission of messages in both directions simultaneously. Thermionic valve amplifiers are employed.

2869. **G. Crisson** [Western Electric Company]. Thermionic Telephone Repeaters. (*British Patent* 145578, June 29th, 1920. Convention date May 20th, 1919. Patent accepted November 4th, 1920.)

2870. **F. Trives.** Long Distance Telephony. (*Bulletin de la Société Française des Électriciens*, 1 (4th series), pp. 109—124, March, 1921.)

A description of a demonstration of the Western Electric Company's thermionic valve telephone repeaters.

2871. **B. Rosenbaum** [E. F. Huth Gesellschaft]. Wireless Repeating Apparatus. (*British Patent* 149235, July 12th, 1920. Convention date August 18th, 1917. Patent not yet accepted.)

In a relaying system for use in wireless, automatically working intermediate stations are provided which transmit the message from the first transmitting station to the final receiving station or to a second automatic intermediate station.

At the intermediate station the incoming message is stored up on a species of telegraphone, and at the end of each message a special call is sent which operates the necessary relays for changing over the intermediate station from receiving to sending, and the message is then retransmitted automatically from the record on the magnetised steel wire of the telegraphone.

(11) AND (12) COMPARISON OF MODULATION METHODS, SPEECH WAVEFORMS, ETC.

2872. **A. S. Blatterman.** Comparison of Modulation Methods in Radiotelephony. (*Radio News*, 2, pp. 360—362, December, 1920; pp. 438—440, January, 1921. *Radioélectricité*, 1, p. 115D, April, 1921—Abstract.)

The author deduces a formula for the detector response to modulated waves and concludes from it that the received telephone current is proportional to the product of the amplitude of the unmodulated C.W. and the modulating waves. Using this as a basis absorption and constant current methods of modulation are compared with each other and with the method using an amplifier between the modulated oscillation generator and the aerial. He concludes that modulation by absorption or detuning is only half as effective as constant current modulation; that four times as many valves are required for absorption modulation as for power

modulation in order to produce the same effect; and that amplification of the modulated output of an oscillator may result in distortion unless the amplifier is carefully designed.

2873. **V. Cheval.** Why is there a Limit to the Audibility of Sounds? (*Bulletin de la Société Belge des Électriciens*, 35, pp. 55—72, March—April, 1921.)

2874. **E. Lübke.** The Shortest Detectable Duration of a Tone. (*Zeitschrift für technische Physik*, 2, pp. 52—53, February, 1921. *Science Abstracts*, 24A, p. 362, Abstract No. 900, May 31st, 1921—Abstract.)

Experiments in air and water showed that the number of periods necessary for the detection of the tone varied with the pitch as follows:—$f = 500$, 5 periods; $f = 1,000$, 9 periods; $f = 2,000$, 15 periods. In two places in the paper 10^{-2} seconds should obviously be 10^{-3} seconds.

2875. **P. Edwards; E. W. Scripture.** The Nature of Vowel Sounds. (*Nature*, 108, pp. 82—83, September 15th, 1921.)

Further correspondence relative to the article referred to in Abstract No. 1647, April, 1921. (See also Abstract No. 1969, June, 1921.) The letters discuss the meaning of the term "fundamental" and the harmonic analysis of speech wave form.

(H.) Radio Receiving Apparatus.

(1) Receiving Circuits; General Descriptions, Etc.

2876. A Radio Receiver for Everybody. (*Scientific American*, 124, p. 354, April 30th, 1921.)

A short illustrated description of a time signal receiver with crystal detector.

2877. Compact Audion Control Unit. (*Science and Invention*, 9, p. 50 and p. 84, May, 1921.)

An illustrated description.

2878. **L. C. F. Horle.** Navy Receiving Equipment. (*Q.S.T.*, 3, pp. 12—14, July, 1920; 4, pp. 8—10, August, 1920.)

Paper presented to the Radio Club of America describing receiving sets used in the U.S. Navy.

2879. **A. H. Lynch.** A New Universal Range Receiver. (*Radio News*, 2, p. 681, April, 1921.)

An illustrated description of a four-valve receiver and amplifier having a range of wavelengths from 150 to 20,000 metres manufactured by **A. H. Grebe Company**.

2880. **A. G. Shalkhauser.** An Ideal Receiving Set for Short and Long Wavelengths. (*Radio News*, 2, pp. 692—732, April, 1921.)

2881. **E. Spon.** A Combined Short and Long Wave Receiver. (*Radio News*, 2, pp. 597 and 656, March, 1921.)

2882. **H. St. J. de A. Donisthorpe** [R. M. Radio, Ltd.]. Wireless Receiving Apparatus. (*British Patent* 160981, January 14th, 1920. Patent accepted April 7th, 1921.)

Describes a portable receiving set constructed in the form of a book, flat spirals being mounted in each cover and tuning effected by varying the angle between them and hence their mutual inductance. The detector is mounted in the hinge of the book.

2883. **J. Robinson** and **H. L. Crowther.** Wireless Receiving Apparatus. (*British Patent* 159377, December 17th, 1919. Patent accepted March 3rd, 1921. *Engineer*, 131, p. 337, March 25th, 1921—Abstract.)

In wireless receiving apparatus the pitch of the note heard in the telephones is controlled by means of a condenser the capacity of which is varied by electromagnetic means controlled by the intensity of the received signals. The condenser may be in the grid circuit (shunted by a leak) of an oscillating valve, so as to change the period of interruption of the oscillations by the grid leak, or may form part of one of the oscillation circuits so that the heterodyne beat note is changed.

2884. **H. P. Rees.** Wireless Receiving Apparatus. (*British Patent* 158455, January 5th, 1920. Patent not yet accepted.)

Relates to the arrangement of compact inductances in receiving units, the inductances

being wound in many layers of short axial length. The separate wavelength ranges may be made up in different units.

2885. **W. J. Picken** and **J. G. Robb.** Wireless Receiving Systems. (*British Patent* 158707, November 11th, 1919. Patent accepted February 11th, 1921. *Engineer*, 131, p. 337, March 25th, 1921—Abstract. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 219—220, September, 1921—Abstract.)

When reception takes place on aerials at a distance from the central common receiver, the received oscillations are amplified before transmission over the land lines so as to reduce the influence of the receptive properties of the land lines themselves.

2886. **E. F. Huth** and **S. Loewe.** Wireless Receiving Apparatus. (*British Patent* 148321, July 9th, 1920. Convention date December 20th, 1915. Patent not yet accepted.)

The wireless receiving apparatus is divided up into a number of separate units, some of which can be changed for altering the wavelength range of the set.

2887. **E. E. Frankis.** Wireless Receiving Apparatus. (*British Patent* 152386, June 13th, 1919. Patent accepted October 13th, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 215—216, September, 1921—Abstract.)

To reduce interference from undesired signals the receiving aerial circuit is provided with two earth connections, one containing the usual coupling coil to the receiver and in addition a coupling to an auxiliary tunable circuit, and the second including a variable condenser. By appropriate adjustments it is claimed that the interfering wave can be cut out.

2888. **R. A. Weagant** [Radio Corporation, U.S.A.]. Wireless Receiving Apparatus. (*British Patent* 146529, July 5th, 1920. Convention date June 18th, 1914. Patent accepted October 29th, 1921.)

Relates to a receiver with circuits tuned to the acoustic group frequency.

2889. **J. J. Aurynger.** Receiving Apparatus. (*French Patent* 507827, March 25th, 1919. Published September 24th, 1920.)

The invention relates to induction apparatus for setting in motion high-frequency oscillations in local circuits. It includes a condenser which comprises an exhausted glass tube having therein a heated filament. The condenser plates are of aluminium and have a central hole through which the filament passes.

2890. **N. Lea** [Radio Communication Company]. Wireless Receiving Apparatus. (*British Patent* 151848, November 6th, 1919. Patent accepted October 7th, 1920.)

Relates to an indicating mechanism geared to the inductance tapping switch and to the variable condenser, so that the wavelength to which the circuit is tuned is always indicated on the scale. The scale is changed with the inductance switch, and the pointer is moved by the condenser.

2891. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 152036, October 7th, 1920. Convention date October 8th, 1919. Patent not yet accepted.)

In a receiver suitable for use both with a frame antenna and a vertical antenna means are provided for compensating for the capacity of the vertical antenna when the frame is employed.

2892. Wireless Receiving Apparatus—System M.W.B. (*L'Électricité pour Tous*, 3, pp. 165—166, June 30th, 1921.)

A short illustrated description of multi-valve receiving and amplifying apparatus manufactured by **M. de Woutres.**

2893. **M. Moye.** The use of Commercial Supply Systems in Wireless Receiving Stations. (*La Nature*, 49(1), pp. 405—407, June 25th, 1921. *Radio News*, 2, p. 863, June, 1921—Abstract. Also *Wireless World*, 9, p. 103, May 14th, 1921.)

Deals with the use of 110-volt D.C. supply mains for feeding the anode circuits of valve amplifiers.

2894. **A. H. Lynch.** Working Two Radio Watches at the same Time. (*Science and Invention*, 9, pp. 248 and 280, July, 1921.)

Describes an automatic switch arrangement for enabling a single operator to maintain watch of two wavelengths simultaneously.

2895. A Receiving Tuner for C.W. (*Q.S.T.*, 4, pp. 5—7, June, 1921.)
An illustrated description.

2896. **K. Richardson.** A High Efficient Super-portable Receiver. (*Radio News*, 2, p. 767, May, 1921.)
An illustrated description of a pocket receiving apparatus.

2897. **C. T. Atkinson.** The Design and Construction of an Efficient Detector Amplifier. (*Wireless World*, 8, pp. 588—590, November 13th, 1920. *Radio News*, 2, p. 772, May, 1921—Abstract.)

2898. **F. J. Rumford.** Reaction Valve Circuits. (*Wireless World*, 9, pp. 69—70, April 30th, 1921.)
Some useful receiving circuits for amateur use.

2899. **J. Robinson.** Some Acoustical Effects in Wireless. (*Wireless World*, 9, pp. 71—78, April 30th, 1921.)
A paper read before the Wireless Society of London with discussion. (See RADIO REVIEW, 2, p. 248, May, 1921, for abstract.)

2900. **F. J. Rumford.** A Simple and Efficient Short Wave Regenerative Receiver. (*Radio News*, 2, pp. 526—527, February, 1921.)

2901. **H. K. Dunn.** Using an Amplifier as a Detector of Long Waves. (*Radio News*, 2, p. 528, February, 1921.)
Relates to the use of an audio-frequency amplifier for direct reception of long wavelength signals.

2902. **L. H. Nijhof.** The Use of Bell Transformers for Heating Filaments of Valves. (*Radio Nieuws*, 4, pp. 243—245, August, 1921.)
An amateur with a 220-volt A.C. supply has replaced his accumulators by 220/5-volt bell transformers. In parallel with the filament are two small 4-volt lamps in series and the grid and anode tapping is made to their middle point.

2903. **G. A. Beauvais.** A Contribution to the Study of Detectors. (*La T.S.F. Moderne*, 2, pp. 161—166, August, 1921.)
A general discussion of the properties of detectors from the point of view of their characteristics.

2904. **F. Duroquier.** The Construction of Radio Detectors. (*La Nature*, 49(2), Supplement pp. 23—25, July 23rd ; pp. 31—32, July 30th ; and pp. 37—43, August 6th, 1921.)
Describes a mode of building three-electrode valves and gives many circuit diagrams of their uses.

2905. **J. S. Brown.** Short Wave Tuning Systems. (*Radio News*, 3, p. 18, July, 1921.)

2906. **G. Hild.** Single Circuit Audion Receiver. (*Radio and Model Engineering*, 1, pp. 4—8, May, 1921.)

2907. **W. H. Bullock.** A Real Receiving Equipment. (*Radio and Model Engineering*, 1, pp. 13—17, July, 1921.)
An illustrated description of a three-valve receiver giving constructional details of the parts.

2908. **P. F. Godley.** Simplified *versus* Three Circuit Regenerative Receivers. (*Q.S.T.*, 5, pp. 7—9, September, 1921.)

2909. **F. E. Pernot.** Receiving Circuit for Frequency Selection. (*Wireless Age*, 8, pp. 20—21, April, 1921.)
Deals with the use of special grouped frequency selective circuits for connection in the anode circuit of a detecting valve.

2910. **M. Moye.** Wireless Receiving Stations using Alternating Currents only. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 396—400, September, 1921.)
A detailed description of means for overcoming the difficulties inherent to the use of an A.C. supply for feeding the L.T. and H.T. circuits of receiving valve amplifiers.

2911. **M. Adam.** The Use of Alternating Current in Radiotelegraphic Receivers. (*Radio-électricité*, 2, pp. 137—139, September, 1921.)

Circuit diagram is given of the suggested arrangement with oscillograms of the currents in various circuits.

2912. **H. St. J. de A. Donisthorpe.** Portable Radio Telegraphic and Telephonic Apparatus. (*U.S. Patent* 1388936, April 28th, 1920. Patent granted August 30th, 1921.)

See corresponding *British Patent* 160981—RADIO REVIEW Abstract No. 2882.

2913. A Single Control Universal Range Receiver. (*Radio News*, 3, p. 205, September, 1921.)

Gives constructional details.

2914. **F. J. Rumford.** Practical V.T. Detector and Two-stage Amplifiers. (*Radio News*, 3, p. 204, September, 1921.)

Gives constructional details.

2915. **J. Scott-Taggart.** Thermionic Detectors. (*British Patent* 166237, July 28th, 1919. Patent accepted July 11th, 1921.)

A special circuit involving the use of two three-electrode tubes coupled to a common telephone circuit. The device is said to act as a limiter.

2916. **W. J. Henry.** Transatlantic Reception *par Excellence.* (*Radio News*, 3, p. 283, October, 1921.)

A short illustrated description of the U.S. Navy Receiving Station at Otter Cliffs.

(2) CRYSTAL AND MISCELLANEOUS DETECTORS AND RECEIVERS.

2917. **R. Dongier.** Contact Detectors. (*Comptes Rendus*, 171, pp. 238—240, July 26th, 1920. *Science Abstracts*, 23A, p. 659, Abstract No. 1650, December 30th, 1920—Abstract.)

Using a crystal contact detector, the point being attached to a diaphragm, a species of telephone was constructed which could be used as an auto-detector in a wireless telegraph or telephone set. Two effects are apparently present, the ordinary rectifying effect and the effect which gives rise to the production of sound.

2918. **A. N. Goldsmith** and **E. T. Dickey.** Radio Taste Reception. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 206—224, June, 1921. *Electrical Review*, 188, pp. 10—11, January 7th, 1921—Abstract. *Popular Science Monthly*, 99, p. 35, August, 1921—Abstract. *Radio News*, 2, p. 363, December, 1920—Abstract. *Electrical World*, 78, p. 131, July 16th, 1921—Abstract. *Science Abstracts*, 24B, p. 463, Abstract No. 928, September 30th, 1921—Abstract.)

Describes experiments made to determine the feasibility of reception of radiotelegraphic signals by the sense of taste. Silver electrodes were used one of which made contact with the inner part of the upper lip of the operator and the other with the tip of his tongue. With a direct current circuit it was found that the observer could detect a potential difference across the electrodes of 0·4 volt. A potential difference of 2·0 volts was considered sufficient for the transmission of signals. With an alternating current circuit these values were not very much different, but the element of fatigue did not seem to be so noticeable and the taste sensation appeared to be more continuous.

In actual experiments using radio reception and 4-stage amplification, it was found possible to detect signals the audibility of which in the detector circuit was 500 or more. It was also found possible to tune in a station by noting when the intensity of the taste sensation was a maximum. But for messages to be read the speed must not be greater than ten words a minute.

(See also RADIO REVIEW Abstract No. 1377, January, 1921.)

2919. The "Excentro" Detector. (*La Nature*, 49(1), Supplement p. 139, April 30th, 1921.)

A short illustrated note describing a completely enclosed type of crystal detector.

2920. **R. Pedegert.** Crystal Detector. (*French Patent* 507108, December 5th, 1919. Published September 6th, 1920.)

The detector is one in which the known properties of galena are employed in a novel manner. The device consists of a container partly filled with mercury and hermetically closed by a plug

of insulating material through which pass two terminals on the inner ends of which are carried galena crystals, which dip into the mercury.

2921. **A. Turpain.** On the Detection of Hertzian Waves. (*Revue Générale de l'Électricité*, 8, p. 513, October 16th, 1920.)

Correspondence with regard to the first invention of a microphonic detector for Hertzian waves. Experiments made by the writer in November, 1894, are quoted.

2922. **R. Audubert.** Rectification at Solid Contacts. (*Journal de Physique*, 7, pp. 209—223, November—December, 1917. *Science Abstracts*, 24A, p. 298, Abstract No. 718, April 30th, 1921—Abstract.)

Describes an investigation of the phenomena of rectification for mixtures of bodies which present in the pure state very different characteristics. Pure materials were mixed together in known proportions and then fused, sulphur being added to prevent oxidation. The resulting solid was then used with a metal point to which various small pressures could be applied.

It was found that the sensibility passes through a minimum value for a mixture corresponding approximately to the entectic. Curves are also given showing the effect of variation of the pressure on the contact. The results show that pressure, temperature and current across the contact all produce the same effects, a cohering action taking place.

2923. **J. Zenneck.** The Sluggishness of Thermal Detectors. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 162—179, March, 1921. *Technical Review*, 9, p. 172, June 14th, 1921—Abstract. *Science Abstracts*, 24B, pp. 364—365, Abstract No. 753, July 30th, 1921—Abstract. *Radioélectricité*, 1, pp. 137D—139D, June, 1921—Abstract.)

A theoretical investigation of the effect of varying degrees of sluggishness on the reception of signals of different kinds both with groups of damped waves and with continuous waves, either direct or with heterodyne.

2924. **A. Bonnefont.** Crystal Detectors for Wireless Signals. (*British Patent* 157778, January 10th, 1921. Convention date November 13th, 1919. Patent not yet accepted.)

Relating to crystal detectors where, in order to facilitate selection of contact point, a searching point can be rotated relatively to the crystal by means of one or more eccentrics.

2925. **S. Oulianine.** Tuned Receiving Apparatus. (*British Patent* 148586, January 29th, 1919. Patent accepted July 29th, 1920.)

Relates to a selective filter based on the audio-frequency tuning of a stretched wire.

2926. **H. M. Dowsett.** Crystal Detector. (*British Patent* 163448, February 14th, 1920 Patent accepted July 17th, 1921. *Engineer*, 132, p. 28, July 1st, 1921—Abstract.)

Relates to the mounting of crystals for detectors.

2927. **E. Wilson.** On Magnetic Detectors. (*Wireless World*, 9, pp. 170—174, June 11th, 1921.)

A paper read before the King's College Wireless Society. The author describes the theory of the magnetic detector, and gives the history of its development. The author suggests the possibility of a further usefulness for the magnetic detector if it is found possible to apply to it a trigger control action to function in a similar manner to the grid of the three-electrode valve.

2928. A New Crystal Detector. (*Radio News*, 3, p. 102, August, 1921.)

2929. **C. Tubandt.** Uni-directional Ionic and Mixed Conductivity in Crystals. (*Electrochemische Zeitschrift*, 26, pp. 358—363, September 1st, 1921. *Science Abstracts*, 24A, pp. 576—577, Abstract No. 1466, August 31st, 1921—Abstract.)

(3) Electron Tube Detectors and Receivers.

2930. **L. M. Clement.** The Vacuum Tube as a Detector and Amplifier. (*Q.S.T.*, 3, pp. 5—9, April; pp. 11—15, May, 1920.)

2931. **J. Scott-Taggart.** Thermionic Valve Receiving Apparatus. (*British Patent* 153681, August 14th, 1919. Patent accepted November 15th, 1920.)

Arrangements of double grid receiving valves are described in which one of the grids is

coupled to the receiving aerial circuit while the second is retroactively coupled to the plate circuit for regenerative amplification or heterodyne oscillation generation.

2932. **J. Robinson, A. K. Macrorie, C. P. Grenfell** and **H. Morris-Airey.** Wireless Reception Apparatus. (*British Patent* 153690, August 18th, 1919. Patent accepted November 18th, 1920.)

An arrangement of receiver is described in which the intensity of the received waves is caused to control the pitch of the note heard in the telephone. For this purpose the oscillating thermionic valve is employed, the oscillations generated having a group frequency which is audible in a telephone in the plate circuit, and which is dependent upon the value of the leak resistance in this grid circuit. This leak resistance is formed by a second three-electrode valve which is connected to the receiving circuits. The apparatus is particularly applicable to direction finding systems.*

2933. **F. W. B. Gill.** Wireless Receiving Apparatus. (*British Patent* 155642, September 22nd, 1919. Patent accepted December 22nd, 1920. *Engineer*, 131, p. 137, February 4th, 1921—Abstract. *Wireless Age*, 8, p. 23, July, 1921—Abstract.)

One of the suggested arrangements is indicated in Fig. 2.

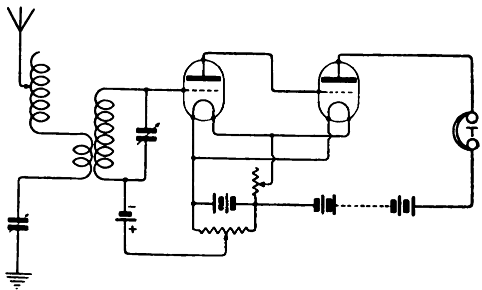

FIG. 2.

2934. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Wireless Receiving Apparatus. (*British Patent* 160941, December 31st, 1919. Patent accepted March 31st, 1921.)

A thermionic valve with a tuned grid circuit and a retroactively coupled plate circuit is started into self-oscillation when waves of the proper frequency are received in the aerial circuit. The change in the steady component of the plate current thus produced destroys the balance in a Wheatstone bridge circuit by altering the potential of the grid of a valve forming one arm of the bridge. The bridge is supplied from a source of audible frequency currents, so that when a signal is received they produce a sound in the receiving telephones connected to the bridge.

2935. **E. O. Hulbert** and **G. Breit.** The Detecting Efficiency of the Single Electron Tube. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 119—132, February, 1921. *Radioélectricité*, 2, pp. 3D—5D, July, 1921—Abstract. *Science Abstracts*, 24B, pp. 269, 270, Abstract No. 540, May 31st, 1921—Abstract. *Revue Générale de l'Électricité*, 9, pp. 183D—184D, June 4th, 1921—Abstract.)

See RADIO REVIEW Abstract No. 1902, June, 1921, for original paper.

2936. **E. F. Huth.** Wireless Receiving Apparatus. (*British Patent* 149240, July 12th, 1920. Convention date October 13th, 1917. Patent not yet accepted.)

In a thermionic receiver for wireless the incoming energy is applied to the anode of

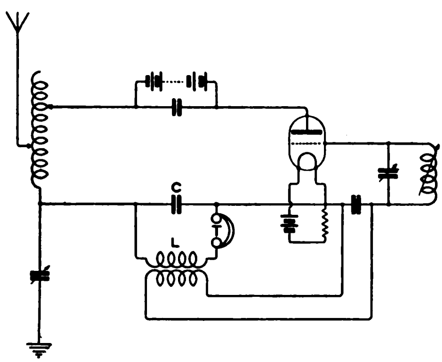

FIG. 3.

* See RADIO REVIEW, 2, p. 248, May, 1921, for further references to this arrangement.

the valve. Low-frequency amplification of the rectified impulses may also be obtained in the manner indicated in Fig. 3. The circuit CLT is tuned to the group frequency of the signals.

2937. **S. Loewe.** Wireless Receiving Apparatus. (*British Patent* 149237, July 12th, 1920. Convention date April 18th, 1918. Patent not yet accepted.)

A modification of the arrangement described in RADIO REVIEW Abstract No. 2938, and using an indirect coupling between the output of the first reversed valve and the input of the amplifier (Fig. 4).

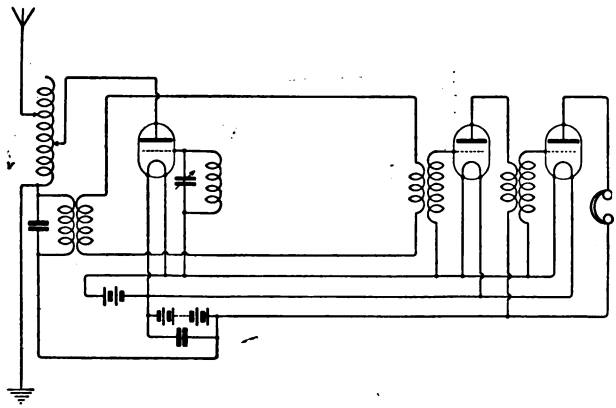

FIG. 4.

2938. **S. Loewe.** Wireless Receiving Apparatus. (*British Patent* 149218, July 12th, 1920. Convention date April 18th, 1918. Patent not yet accepted.)

In thermionic valve apparatus for receiving wireless signals the received oscillations are led to the anode of the receiver, and the output energy is taken from the grid circuit of the receiver. This minimises retroactive self-oscillation. The suggested arrangement is shown in Fig. 5, in which v_1 is the first valve having its anode connected to the aerial circuit and its grid joined to the input circuit of the next valve.

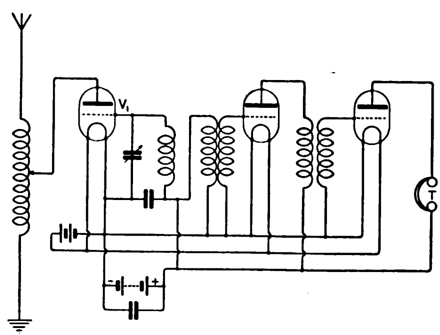

FIG. 5.

2939. **A. Williams** and **H. St. J. de A. Donisthorpe** [R. M. Radio, Ltd.]. Thermionic Valve Receivers. (*British Patent* 159679, December 16th, 1919. Patent accepted March 10th, 1921.)

Relates to a receiver comprising a number of valve units which may be joined in cascade by appropriate plug connections.

2940. **J. Robinson** and **H. L. Crowther.** Wireless Receiving Apparatus. (*British Patent* 159683, December 17th, 1919. Patent accepted March 10th, 1921.)

An addition to *British Patent* 153690 * in which the intensity of the incoming signals is arranged to vary the resistance connected to an oscillation circuit. Two oscillating valves are

* RADIO REVIEW Abstract No. 2932.

used so that the resistance change produced by the incoming signal alters the pitch of the beat note.

2941. **J. Robinson** and **H. L. Crowther**. Wireless Receiving Apparatus. (*British Patent* 159959, December 5th, 1919. Patent accepted March 7th, 1921.)

In a C.W. receiving system a valve oscillating at an audible frequency is arranged to affect the grid potential of the receiving valve so that the positive peaks of the L.F. oscillations just bring the receiving valve to the detecting point.

2942. **R. A. Weagant** [Radio Corporation of America]. Valve Oscillation Generator. (*U.S. Patent* 1384108, April 8th, 1914. Patent granted July 12th, 1921.)

Means for generating electrical oscillations for receiving purposes, comprising a vacuum tube oscillator circuit in which an adjustable non-inductive resistance is connected between two of the electrodes of the vacuum tube.

2. Books.

THERMIONIC TUBES IN RADIOTELEGRAPHY AND TELEPHONY. By John Scott-Taggart. (London: *The Wireless Press, Ltd.* 1921. Pp. xxiii + 424. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. Price 25*s*. net.)

Although the title of this book gives the impression that the tubes dealt with are for radiotelegraphic and telephonic purposes only, the information contained therein is found to cover the use of thermionic tubes for practically all the known purposes to date.

For the beginner in thermionic tube or thermionic valve work (as it is usually termed in this country) the elementary theory of thermionic currents given in Chapter I. will be found of great value.

In this chapter the two-electrode valve principles are extensively and carefully treated in such a way as to prepare the student for the more complicated forms and characteristics of the three-electrode and other valves.

Chapter II. is devoted to three-electrode valve theory and contains a large number of useful characteristic curves together with diagrams of the circuits used in obtaining these characteristics.

The valve as a detector and as an amplifier is dealt with in Chapters III. and IV. respectively.

The curves given in Chapter III. of the detector valve have been prepared in a most comprehensive manner.

Retroactive amplification theory and practice is skilfully explained in Chapter V. and the complete set of diagrams of reactively coupled circuits cover most of those in use.

Chapters VI., VII. and VIII. deal with high and low-frequency amplifiers in an able manner, giving no superfluous mathematical equations. This will be appreciated more by the beginner and practical student than by the academically inclined.

The reception of continuous waves with circuit diagrams is described in Chapter X.

Separate heterodyne and auto-heterodyne reception is fully dealt with, but no mention is made of the earlier methods of C.W. reception which include tikker or chopper circuits. As valve heterodyne or beat reception is approximately twenty-five times as sensitive as the older systems the omission of any of these cannot be considered serious.

Valve transmitting systems for C.W. and telephony are diagrammatically illustrated and described in Chapters XI. and XIII. These chapters include useful historical references to the many patented systems.

The distance ranges, comparative and actual, of the various transmitting systems have not been attempted in this volume. This is perhaps a drawback as it is as necessary to have an approximate idea of the transmitting and receiving range of the apparatus as to know how it functions, even though it must be admitted that local conditions play as important a part as actual transmitting and receiving efficiency.

The dynatron and miscellaneous valve devices including Turner's relay are briefly treated in Chapters XIV. and XV.

It is a book that can be recommended to all classes of physical and wireless students.

W. A. APPLETON.

LES TUBES À VIDE. By Paul Dapsence. (Paris: *G. Péricaud.* Second Edition. 1921. Pp. 50. 8⅜" × 5⅜". Price fr. 2.50.)

A general instructional book primarily written for the amateur, it has chapters devoted to Ionic Electricity, the General Properties of Vacuum Tubes, General Theory, and Practical Sets.

The explanations are helped by reference to the characteristic curves of the valves, and all mathematics is excluded. Numerous circuit diagrams are given for different arrangements of high and low-frequency amplifiers, and a few illustrations of commercial instruments are included.

P. R. C.

NOTIONS ÉLÉMENTAIRES DE TÉLÉGRAPHIE SANS FIL, ET CONSTRUCTION PRATIQUE DE POSTES RÉCEPTEURS. By Jean Rémaur. (Paris: *Librairie Générale Scientifique et Industrielle Desforges.* 1921. Pp. 116. 8¾" × 5¼". Price not stated.)

As may be gathered from the title of this book, it is written at least in part for the wireless amateur or experimenter. In bulk, however, it is designed as an elementary text-book on wireless in general. It commences with a consideration of the oscillatory discharge of a condenser, illustrated by hydraulic analogy. Chapter II. discusses coupled circuits and resonance curves, and Chapter III. the principles of wave transmission, aerials, earth connections, etc.

Chapter IV. is devoted to C.W. transmission, and includes brief descriptions of the mode of establishing continuous oscillations by arcs, alternators and thermionic valves; and Chapter VI. describes various forms of detectors, and the three-electrode valve detector in particular.

The second part of the book contains five chapters giving constructional details for various parts of an amateur receiving equipment; while in the third part general information is included with regard to the Morse code, time signals, etc., and the codes used for the transmission of meteorological messages.

P. R. C.

A CATALOGUE OF BRITISH SCIENTIFIC AND TECHNICAL BOOKS. Prepared by a Committee of the British Science Guild. (London: *The British Science Guild.* 1921. Pp. xviii + 376. 8½" × 5½". Price 10*s.* net.)

A committee of ten members of the British Science Guild (whose headquarters are at 6, John Street, Adelphi, London, W.C. 2) has prepared a most useful catalogue of scientific books which are at present in print in this country. It is divided into fifty main sections covering all the chief branches of science and engineering, and each of these is in most cases further subdivided. In each section or sub-section the books are indexed under the authors' names, arranged in alphabetical order, and extensive name and subject indexes are also added.

The information given appears to be very complete and includes the date of the most recent edition or impression. A useful addition is the list of publishers' names and addresses which is given at the end of the catalogue.

P. R. C.

Books Received.

PREPARED RADIO MEASUREMENTS WITH SELF-COMPUTING CHARTS. By Ralph R. Batcher, E.E. (New York: *Wireless Press, Inc.*; London: *The Wireless Press, Ltd.* 1921. Pp. 132. 8¾" × 6". Price 10*s.* 6*d.* net.)

LA THÉORIE ET LA PRATIQUE DES RADIOCOMMUNICATIONS—II. LA PROPAGATION DES ONDES ÉLECTROMAGNÉTIQUES À LA SURFACE DE LA TERRE. By Léon Bouthillon. (Paris: *Librairie Delagrave.* 1921. Pp. xv + 340. 10" × 6½". With 133 figures. Price 20 gns.)

FIFTY YEARS OF ELECTRICITY: THE MEMORIES OF AN ELECTRICAL ENGINEER. By J. A. Fleming, M.A., D.Sc., F.R.S. (London: *The Wireless Press, Ltd.* 1921. Pp. xi + 371. 9¾" × 7¼". Price 30*s.* net.)

DIRECTIVE WIRELESS TELEGRAPHY, DIRECTION AND POSITION FINDING, ETC. By L. H. Walter, M.A., A.M.I.E.E. (London: *Sir Isaac Pitman & Sons, Ltd.* 1921. Pp. xii + 124. 6½" × 4". With 57 diagrams and illustrations. Price 2s. 6d. net.)

RAYS OF POSITIVE ELECTRICITY AND THEIR APPLICATION TO CHEMICAL ANALYSIS. By Sir J. J. Thomson, O.M., F.R.S. (London: *Longmans, Green & Co.* 1921. Pp. x + 237. 8¾" × 5¾". With 9 plates and 42 figures. Price 16s. net.)

THE FRAMEWORK OF WIRELESS TELEGRAPHY. A New Theory of Electric Wave Sources and Propagations, with Rational Applications. By R. C. Galletti di Cadilhac. (London: *Crosby Lockwood & Son.* 1921. Pp. 48. With 6 diagrams. 8½" × 5½". Price 3s. 6d. net.)

THE SIGNAL SERVICE IN THE EUROPEAN WAR OF 1914—1918 (FRANCE). By R. E. Priestley, M.C., B.A. (Late Major, R.E.). Published by the Secretary, the Institution of Royal Engineers, and by the Signals Association. (Chatham: *W. & J. Mackay & Co., Ltd.* 1921. Pp. xvi + 359. 9½" × 6". With 20 plates. Price not stated.)

Correspondence.

TRIODE CHARACTERISTICS WITH HIGH GRID POTENTIAL.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—In the November issue of the RADIO REVIEW Mr. Bartlett suggests that we should interpret the form of triode characteristics as indicating a pronounced lateral collection of electrons by the grid whenever the grid potential v_g is greater than 0·8 times the anode potential v_a. He considers this "snatching" action of the grid as the cause of the peculiar potential-current characteristics in the region where v_g is about equal to v_a whereas I think that secondary electrons are the main influencing factor. Probably the best way of differentiating between the two theories is by saying that Mr. Bartlett assumes that the electrons tend markedly to follow the lines of force whereas I think that they do so only to a very limited extent.

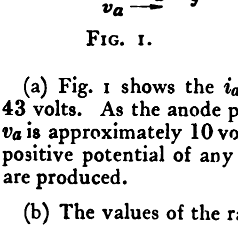

FIG. 1.

Mr. Bartlett states that the bend of the $i_a - v_g$ characteristic always occurs when $v_g = 0{\cdot}8\ v_a$ but I do not find this to be the case. For example at low potentials (*e.g.*, v_a below about 10 volts) no bend at all occurs, and it is just at these low potentials that one might expect the pronounced "snatching" contemplated by Mr. Bartlett. I interpret the absence of the bend in these low voltage characteristics as indicating that no secondary electrons are produced at the anode when v_a is less than 10 volts or so.

As experimental results which appear to me to decide quite definitely between the two theories I submit the following:—

(a) Fig. 1 shows the $i_a - v_a$ characteristic of a B triode for a fixed grid potential of 43 volts. As the anode potential increases the number of electrons reaching it increases until v_a is approximately 10 volts, above which the current falls. I cannot see how increasing the positive potential of any electrode can decrease the current to it unless secondary electrons are produced.

(b) The values of the ratio $\dfrac{\text{number of secondary electrons}}{\text{number of primary electrons}}$ obtained from my interpretation are almost identical with those obtained by Professor Millikan and G. Barber throughout the whole range of impact potentials with which they worked.

(c) The question as to whether the electrons follow the lines of force to any marked extent or not seems to be definitely settled by the determination of the i_g/i_a ratio for values of v_a equal to v_g. In such a case it may be shown that the ratio of the number of lines of force ending on the grid to the number ending on the anode is equal to the amplification factor and

thus if pronounced "snatching" were present we should expect the i_g/i_a ratio to be 8 to 10 in most receiving triodes whereas it is usually about 0·25 to 0·30 or about equal to metal-space ratio of the grid. The remarkable constancy of the ratio for all values of $v_a = v_g$ when saturation has been attained was first discovered by Dr. van der Pol.

The truth is, of course, that Mr. Bartlett's reasoning contains a very fundamental error in electrostatics. It is a commonplace electrical theory that it is dangerous to deal with *resultant* charges on electrodes instead of potentials and potential gradients. Thus Mr. Bartlett states that until the value of v_g is equal to $0{\cdot}8\ v_a$ the resultant charge on the grid is negative and the grid is actually repelling electrons. We are told that it is only an accident that the electrons reach the grid at all and we naturally wonder why the accident should take place quite suddenly when the grid potential is brought from negative to positive values. We have always previously thought that this particular critical point was accounted for by the change in sign of the potential gradient between that part of the filament opposite the grid and the grid itself but Mr. Bartlett discountenances this view since for him the grid is always repelling electrons when the *resultant* charge on the grid is negative, even though v_g may be positive. And thus our difficulties would go on were we not to remember the simple fact that the grid can have a positive charge on the side facing the filament and a negative charge on the anode side and although its *resultant* charge may be negative it will attract electrons on the filament side and repel them on the anode side.

I mentioned above that it was dangerous to deal with *resultant* charges on the electrodes and for an illustration of this I cannot do better than to indicate the trouble into which we are led by Mr. Bartlett's own result. For example he has found that $v_g = 0{\cdot}8\ v_a$ is a critical point and that so long as $(v_g - 0{\cdot}8\ v_a)$ is negative the resultant grid charge is negative but when $(v_g - 0{\cdot}8\ v_a)$ assumes positive values electrons are attracted and true grid current begins. Let us take an example. Let us assume that v_g is fixed at -20 volts and that v_a is taken through continuous values from -24 volts to -26 volts. It requires simple algebra to prove that the resultant charge on the grid reverses in sign from negative to positive values when $v_a = -25$ volts. We thus are led to expect a sudden increase in grid current at this point but it is a commonplace that no such increase occurs. Indeed no grid current at all occurs in a hard tube until v_g itself assumes positive values.

I should be the last to say that all difficulties are cleared away by the secondary electron theory. For example the question of emission velocities is still unsettled but I hope that some experiments now in hand will help. My view is that the pure "snatching" theory contemplated by Mr. Bartlett raises more difficulties than it solves whereas a secondary electron theory explains at least the main effects.

E. V. APPLETON.

Cambridge,
November 13th, 1921.

A HIGH-FREQUENCY MACHINE OF GREATER SPECIFIC POWER AND HIGHER EFFICIENCY.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—The high-frequency alternator marketed by the Société Française Radio-Électrique possesses a further marked advantage which I omitted to mention in my article which appeared in the RADIO REVIEW for August, 1921. This advantage lies in the particular aptitude of this alternator for parallel working.

In alternators coupled in parallel, the stator reactance can always be balanced to any required extent by capacities and the synchronising torque then becomes greater the lower the apparent stator resistance at the frequency considered.

Now, as shown by the writer, the losses due to the output are much smaller in the alternator having a reduced number of stator slots than in the ordinary machine. Hence the apparent resistance is much lower in the first type of machine and consequently the parallel coupling of such machines becomes relatively easy, as has been proved in practice.

MARIUS LATOUR.

Paris,
November 23rd, 1921.

THE RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. III FEBRUARY, 1922 No. 2

Editor:
PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.

Assistant Editor:
PHILIP R. COURSEY, B.Sc., F.Inst.P., A.M.I.E.E.

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Editor: Prof. G. W. O. HOWE, D.Sc., M.I.E.E. Asst. Editor: PHILIP R. COURSEY, B.Sc., A.M.I.E.E.

SUBSCRIPTION RATES.—£3 per annum, post free. Single copies, 5/-, or post free, 5/3.

Vol. III. No. 2 — Registered at the G.P.O. for transmission by Magazine Post to Canada and Newfoundland. — FEBRUARY, 1922

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THE RADIO REVIEW

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THE
RADIO REVIEW

VOL. III FEBRUARY, 1922 NO. 2

Editorial.

The Design and Construction of Towers and Masts for Radio-telegraphy.—One of the first discoveries made by Marconi in his earliest experiments in Italy was that the transmitting efficiency depended on the height of the transmitting antenna, and although there have been suggestions from time to time that the elevated transmitting antenna might be replaced by a low horizontal conductor, it is now generally recognised that height is of prime importance. It is fairly safe to say that the designers of all the modern high-powered stations would welcome the possibility of increasing the heights of their antennæ if it could be done without adding enormously to the cost of the station. Unfortunately the cost increases very rapidly with the height and the designer has to decide in each case to what height he is justified in going. This situation is relieved to some extent by the use of a multiple aerial since this permits the use of a very extensive system of overhead wires and of very large currents without introducing excessive losses.

At the present moment many attempts are being made to increase the efficiency of transmitting antennæ so as to bring the ratio of the radiated power to the input to the antenna up to a more reasonable value than it had in the majority of cases. The first step in this direction has been directed to reducing the losses in the earth in the immediate neighbourhood of the antenna and the recent papers by Meissner, in Germany, and Eckersley, in this country have shown what very great economies are possible by proper design of the earthing system or counterpoise.

A subject about which very little is known is the loss of power occurring in the masts and stays. It is not a subject that lends itself very readily to research on a large scale and any results obtained on small scale models would be difficult to apply to the large scale example. The best design of mast or tower involves so many problems apart from the purely electrical ones that no hard and fast rules could be laid down; we feel sure, however, that the time has come when more attention should be paid to the effects of the masts in the radiation of power from the antenna. What are the relative merits of wood and steel, of self-supporting towers and stayed masts, if of steel, should they be earthed and continuous or insulated and sectionalised, what degree of sectionalisation is desirable in the masts and in the stays? These are some of the problems awaiting a thorough examination and there are others closely allied, concerning the advisability of maintaining a greater distance between the masts and the actual antenna, the precautions which

might be applied to all terminal and junction points of the antenna to increase the corona limit by proper shielding, the reduction of the losses in the earth at the foot of an insulated mast. These questions are not of interest to the designer of high-powered stations only, but to all radio engineers. In the station working over 500 or 1,000 miles the improvement of the radiation efficiency is of very great importance, since it may enable one valve to be used instead of two, or the valves to be used under conditions more conducive to long life, and the purity of the emitted wave to be improved so as to cause less interference with other stations.

It is not a difficult matter to make an approximate determination of the radiation efficiency of an antenna. The total effective resistance including the radiation resistance, or radiance, as Brillouin prefers to call it, can be determined in the usual way by observing the effect on the antenna current of inserting a known non-inductive resistance, without varying the E.M.F. induced in the accurately tuned aerial from a weakly coupled primary circuit. The radiation resistance can be calculated approximately from an assumed effective height of antenna; this can be estimated within 5 or 10 per cent., depending on the data at one's disposal, and we suspect that a knowledge of the radiation efficiency to this degree of accuracy would be sufficient to cause many antennæ to undergo a period of reconstruction.

Applications of the Thermionic Valve.—Probably no piece of electrical apparatus is so adaptable to a variety of purposes as the three-electrode valve and this with little or no modification of its construction. This wonderful adaptability is well illustrated in the high-speed apparatus described by Lieut.-Colonel Cusins in his paper before the Wireless Section of the Institution. The transmitter and receiver contain together eleven valves, which have, between them, eight different functions to perform. Of the two in the transmitter one is the main high-frequency generator while the other acts as a variable control resistance in its grid circuit. In the receiver, three serve as a high-frequency amplifier, one as a valve relay, one as a low-frequency generator, one as a valve-relay control valve, one as a direct-current amplifier, and two in conjunction as a double-current valve relay. Although the paper described the progress made in what the author called the mechanicalisation of wireless telegraphy, this progress is only made possible by the elimination of mechanical links, except at the beginning and end of the chain, and their replacement by three-electrode valves.

Another Wireless Slide Rule.—In many calculations in connection with radio and high-frequency circuits frequent use is made of the well-known formula $\lambda = K\sqrt{CL}$. Abacs, charts and similar devices have often been prepared to facilitate the frequent use of this and similar formulæ, and Messrs. B. Hodgson and S. Brydon have recently prepared a special slide rule to enable direct readings of capacity, inductance and wavelength to be obtained. The range of the inductance scale is from 1 to 10,000 microhenries, and forms the upper fixed scale of the rule; the capacity scale runs from

0·00001 to 0·1 microfarad and forms the lower scale on the slide; and the wavelength scale (fixed) is in two parts running from 6 to 600 and 600 to 60,000 metres. Four index arrows are marked on the slide, two being in red and two in black, the black arrows corresponding to the above-mentioned capacity scale; and the red ones for use with a second capacity scale engraved with red figures between 0·01 and 100 jars. By selecting the appropriate index arrow, the range of the inductance scale can be extended when necessary, without appreciably impairing the direct-reading qualities of the rule.

Theoretical and Practical Aspects of Low Voltage Rectifier Design when employing the Three-electrode Vacuum Tube.*

By R. D. DUNCAN, Jun.

Chief Engineer, U.S. Signal Corps Research Laboratory, Bureau of Standards.

Introduction.—The problem of generating high continuous voltages required for operating radio telephone and telegraph equipment of the thermionic type is one in which, under certain conditions, difficulties are encountered in obtaining a *satisfactory* practical solution. The method customarily in use is that wherein a converter or motor-generator is employed, operating either from storage batteries or from a local power source; where relatively high powers with attendant higher anode voltages are required, and where alternating current is available, the transformer-rectifier combination has come into use. Radio transmitting apparatus employing this latter arrangement was first described a number of years ago by Langmuir,† and has since been developed for commercial purposes both in the United States and in Europe.

The necessity for employing dynamotor or motor-generator equipment, even where low transmitting powers are concerned, presents serious obstacles to the practical and commercial adoption of radio apparatus except where skilled attendance is available, as would be the case in a centralised plant. Occasions have often arisen, and will no doubt continue to arise with increasing frequency, where skilled attendance not only will not be available, but where radio and kindred apparatus, to be acceptable for comparative isolated installation, must be capable of operation and maintenance by entirely unskilled personnel. A notable example of a type of service which demands such apparatus is that of "Line Radio" or "Wired Wireless" where the principal object is to place at the disposal of the unskilled operator multiplexing telephone and telegraph equipment which basically requires the generation of high continuous voltages. The transformer-rectifier com-

* Received October 1st, 1921.

† **I. Langmuir,** *Proceedings of the Institute of Radio Engineers,* 3, p. 284, 1915.

F 2

bination has been found to give satisfactory and dependable operation for this type of service.

With the increasing use of rectifying equipment, the question of its design to meet specific requirements becomes one of importance. It has been discussed by Hull,* Fortescue,† and van der Bijl,‡ who have dealt in a more or less general manner with conditions which prevail when relatively high powers and extremely high voltages are concerned and where the "hard" or high vacuum type of rectifier tube is employed. Furthermore in these discussions it is implicitly assumed that the rectifier tube may be constructed to have the particular voltampere characteristic desired. Where these conditions are not fulfilled the theory, as developed, requires a number of modifications as are hereinafter noted.

The investigations with which the present paper is concerned as explained elsewhere, by virtue of restrictions imposed by the conditions of development, operation, and maintenance of the apparatus, contemplated the use of standard forms of the three-electrode tube as the rectifier, in preference to a special type of tube. The problem is then restricted to the determination of the design constants of the transformer which will operate properly with the rectifier tube in question and furnish the high voltage required for rectification.

It is the object of this paper to discuss from the preceding standpoint, the theory and design of the low voltage rectifier for furnishing plate voltage required in the operation of relatively low power radio telegraph and telephone transmitters of the thermionic type. The theory is developed essentially from a practical standpoint and does not pretend to rigorousness; wherever it was considered advisable, empirical relations have been introduced, which were found by experiment to have an accuracy sufficient for design purposes. Based upon the theory, equations have been worked out from which the design information, required to carry through the design of the rectifier transformer may be obtained. In its general form, the theory follows along the lines laid down by Fortescue, but contains certain differences which are apparent upon comparison of the two texts.

General Considerations.—When the design of rectifying apparatus is considered, for operation with a specific type of load, such as that presented by the plate-filament circuit of the transmitting tubes of a radio telephone set, a number of factors must be taken into account, of which the following are the most important:—

(*a*) Source of power and frequency available.
(*b*) Type of rectifier tube to be used.
(*c*) Magnitude of rectified voltage and current required.
(*d*) Magnitude of ripple permissible in the rectified voltage.
(*e*) Power and current required to be delivered by the rectifier transformer.

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* **A. W. Hull,** *General Electric Review*, 19, p. 177, 1916.

† **C. L. Fortescue,** *Proceedings of the Physical Society of London*, 31, p. 319, 1919.

‡ **van der Bijl,** "The Thermionic Vacuum Tube" (*McGraw-Hill Publishing Co.*), Chapter IV.

In the following the bearing which these various factors have upon the design of the apparatus is discussed :—

(*a*) Unless otherwise stated the standard [U.S.] commercial frequency of 60 cycles per second is adopted throughout as a basis for discussion.

(*b*) The choice of the type of rectifier tube is governed largely by conditions under which the rectifying apparatus is developed and under which it will operate when in use. Where facilities are immediately available for the construction of special types of vacuum tubes, and where the question of maintenance and operation of equipment, which includes different types of transmitting tubes, does not present serious difficulties, the two-electrode tube is the logical choice. Where, however, the conditions of development are unfavourable to the consideration of a special type of rectifier tube, and where the conditions of operation demand the simplest types of apparatus with the minimum requirements for maintenance, it is necessary to restrict the number of types of tubes to a minimum. For these reasons, in the apparatus development described in part herein, the three-electrode tube, of standard construction, was adopted for use as the rectifier. This type of the tube, however, is not an efficient power rectifier, because of its relatively high internal resistance which latter quantity may be reduced and operation materially assisted by connecting the grid and plate together. Though the region of operation of the tube with such a connection is restricted to comparatively low plate voltages, experiment has shown that better results are so obtained than with the grid at the same potential as the filament or even positive thereto.

If the rectifier tube is of the coated filament type with a consequent high electron emission, the inability to operate continuously at full saturation electron current is an additional factor which militates against its efficient working, since the complete emission of electrons may never be utilised; in addition the requirement is imposed that the current flowing through the tube may not exceed a maximum value as the excessive heating of the electrodes attendant to high currents may cause destruction of the tube, resulting from gas ionisation and kindred effects.

Where extremely high voltages are dealt with, the voltage drop within the tube is in general negligible compared to the applied voltage, and need not be considered ; however, in the case of comparatively low anode voltages, for accurate design results, it must be taken into account.

The rectifier tubes with which the present investigation is concerned were of the coated filament type and were designed for operation on low plate voltages; in the theoretical consideration of the conditions of rectifier operation, as hereinafter outlined, as well as in the experimental investigation, described in part, the problem was approached, with the limiting provisions in mind which are imposed by the use of such tubes. In a following section reference is again made to the part played by the voltage drop within the tube and a method is described for measuring the same.

(*c*) The magnitude of the rectified voltage and current which will be obtained are functions of the character of the load, which, besides the actual load resistance, includes whatever smoothing out or filtering capacities and

inductances there may be in the circuit. The value of the final load resistance is obtained from direct measurements of the D.C. plate current and plate voltage of the radio transmitter while in operation. Values of this resistance as met with in practice may vary from 1,000 to 5,000 ohms.

(*d*) The variation in the plate voltage resulting from imperfect smoothing out of the rectified voltage gives rise to a form of modulation of the high frequency output of a radio telephone transmitter in the same manner as does the voice operating through the means of the modulating circuits. This is true whether rectified voltage or continuous voltage from a direct current generator, is applied. If rectified voltage is employed, the fundamental frequency of the ripple will be the same as, or twice that of, the fundamental frequency of the alternating current source, depending upon whether *half-wave* or *double wave* rectification is employed; the harmonics

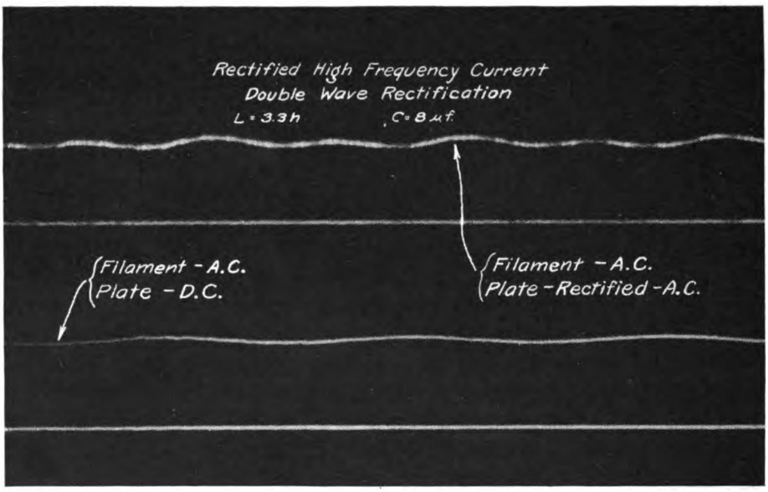

Fig. 1 (*a*) (*c*).

resulting from irregularities in the original wave, and from rectification will suffer modification similar to the fundamental frequency. The amplitude of the ripple may be reduced by means of smoothing out condensers or, if extreme refinement is required, by multi-mesh filter circuits.* When the plate voltage is obtained from a direct current generator of the ordinary type, if special attention is paid to the method of brush mounting, the modulating effect of the commutator ripple may be reduced to where it is not more than 5 per cent. of the entire output. Due to the relatively high fundamental frequency of this type of ripple, this percentage may be further reduced without difficulty, by means of filter circuits. When, however, the plate voltage is of the rectified alternating variety, and the ripple frequency low,

* A discussion of such application of filter circuits is given in the "Thermionic Vacuum Tube" by van der Bijl.

for example, 120 cycles per second, without the use of excessively large capacities and inductances, a ripple amplitude of between 5 per cent. and 10 per cent. is as close to the minimum which may be obtained.

In addition to the modulation produced by variations in the plate voltage of the transmitting tubes there is produced a similar, though not so pronounced effect, if the filaments of the latter are energised by alternating current; this results from the periodic variation in the potential of the filaments of these tubes.

The modulating effect of the plate and filament voltage ripples was investigated with the aid of an oscillograph and under actual transmitting and receiving conditions. Representative oscillograms are given in Figs. 1 (*a*), (*b*), (*c*) and (*d*), in which are shown graphs of the rectified high frequency current

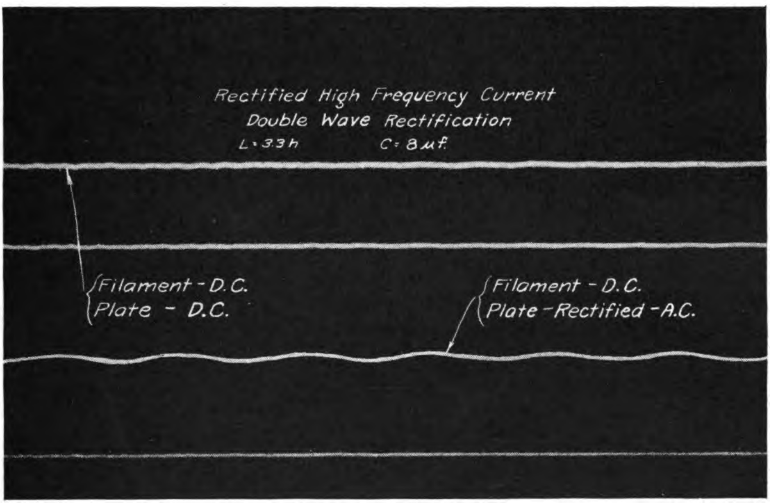

FIG. 1 (*b*) (*d*).

obtained from a standard radio telephone transmitter operating with both alternating current (60 cycles) and direct current energisation. In Fig. 1 (*a*) is shown the full alternating current condition, viz., with the filaments of the radio tubes energised by alternating current and the plates supplied with rectified voltage; in Fig. 1 (*b*), the full direct current condition, and in Figs. 1 (*c*) and (*d*), the combined alternating and direct current conditions as indicated. The oscillograms were obtained with a smoothing out capacity and inductance, in the load circuit, of the rectifier (see Fig. 2) of values respectively equal to 8 microfarads and 3·3 henrys. Assuming the modulation to be symmetrical upwards and downwards about a mean or unmodulated value, it is estimated from the oscillograms that the modulation due to the combined plate and filament effects lies between 5 per cent. and 10 per cent. Since the modulation produced by the voice (not shown in the

oscillograms) is of the order of 90 per cent. upwards and downwards, it is not to be expected that at a distance, telephonic reception will be seriously interfered with by the filament and plate ripples. This conclusion is confirmed by actual reception tests, as over distances small compared to the normal range of transmission of the particular radio transmitter utilised, a ripple modulation of amplitude shown on the oscillograms was hardly observable, and not at all objectionable. There was little to choose between the full alternating current and full direct current conditions. When telegraphic transmission alone is concerned in which the presence of a ripple of relatively large amplitude is not so serious, the smoothing out or filtering capacity may be greatly reduced in value; under this condition the signal received on the beat note principle still maintains its bell-like note and is quite distinctive in character.

(*e*) The power and current requirements of the transformer are discussed in detail in the next section.

Theory of Circuit Operation and Derivation of Design Equations.—In Figs. 2 (*a*) and (*b*) respectively are shown the standard circuits of half-wave and double wave systems of rectification; in Figs. 3 (*a*) and (*b*) are given the current and voltage curves which obtain for the two conditions. The load circuit is represented in Figs. 2 (*a*) and (*b*) by a capacity in parallel with the load resistance. If, as is the case with a large class of radio telephone transmitters, an inductance is included in series with the load resistance, the behaviour of the circuit is somewhat altered, which effect is reflected in the equations. The presence of the inductance assists only slightly in reducing the plate voltage ripple with values of load resistance normally met with in radio apparatus. It is to be noted in this respect that it is of little practical value to attempt to secure such refinement in smoothing out the voltage supplied to the plates of the radio transmitting tubes, since in general the filaments of the latter are energised from alternating current and the modulating effect thus produced will more than annul this advantage. Both conditions are considered in the following.

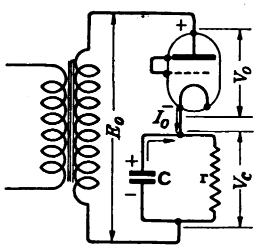

FIG. 2 (*a*).

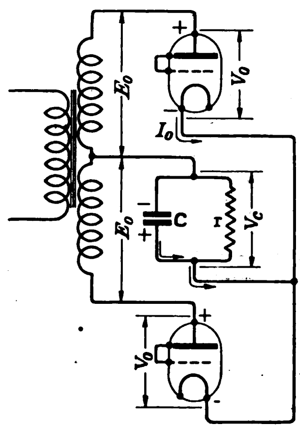

FIG. 2 (*b*).

Referring to Figs. 2 (*a*) and 3 (*a*), the operation of the half-wave circuit may be explained as follows: Neglecting the presence of transients, when the transformer secondary voltage E_0 (maximum value) is initially attained, the capacity C is charged to a voltage less than the maximum voltage E_0 by the maximum voltage drop, V_0, in the rectifier tube; this will be very

approximately true regardless of the part of the cycle of voltage E_0 at which the circuit is closed. Since the rectifier tube is assumed to have perfect unilateral conductivity, current will flow through the tube in the direction of the arrow only when the plate is positive with respect to the filament; the condenser will therefore be charged with the terminal connected to the filament, as positive. After being charged the condenser will attempt to discharge through the resistance branch and through the tube, as shown by the arrows, and in so doing will build up across the tube a voltage which opposes the applied voltage; no current will pass through the tube until this back E.M.F. is overcome. When the applied voltage maintains the plate negative with respect to the filament, no charging current will flow and the condenser will discharge through the load resistance in accordance with well-known laws. Referring to Fig. 3 (*a*), as shown from the previous cycle, at the time $t_1 = t_2 = 0$, the voltage across the condenser is somewhat greater than V_c' and is decreasing in value, while the applied voltage is increasing, and is opposing in sign. When the latter becomes the greater as at A, a varying current of maximum value I_0 will flow through the tube until the time t_1 has elapsed, viz., at point B, and during the greater portion of this time, the condenser voltage is increasing. The net result of the charging and discharging action is that there is applied to the actual load resistance r a continuous voltage of variable amplitude. Though the charging and discharging time intervals are unequal, and the manner of variation of charging and discharging, dissimilar, no great error is incurred in assuming that the average discharge voltage is equal to the arithmetical mean of the maximum condenser voltage, V_c, occurring at time t_1, and the minimum voltage V_c' occurring at time t_2. On the assumption that this average voltage constitutes the fixed component, the voltage variation may be considered as being the result of superposition, upon this fixed component, of an alternating component of maximum amplitude $\frac{V_c - V_c'}{2}$, and of fundamental frequency equal to the frequency of the applied voltage. It is of course desirable to reduce the amplitude of this alternating component to a minimum. It is observed that the current flowing through the rectifier tube, at every

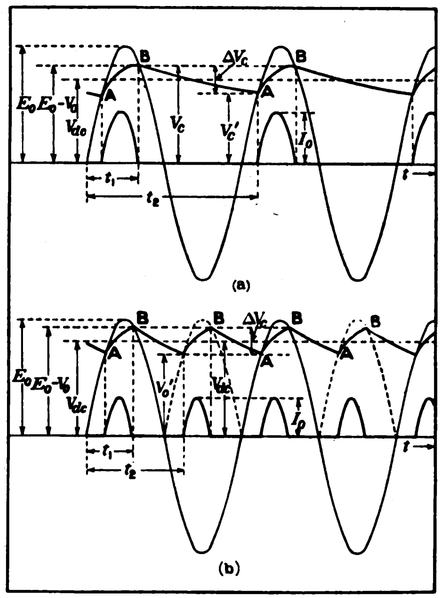

FIG. 3.

instant during passage, is varying and does not remain fixed in amplitude, as was assumed by Fortescue for the case of a hard tube.

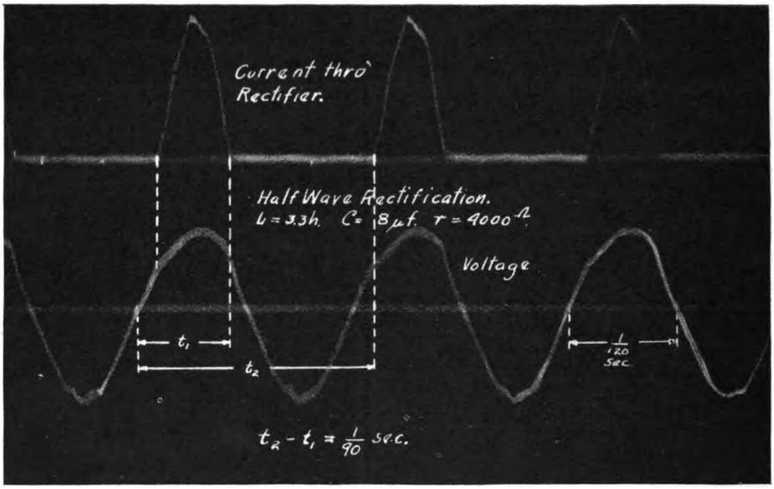

FIG. 4 (*a*).

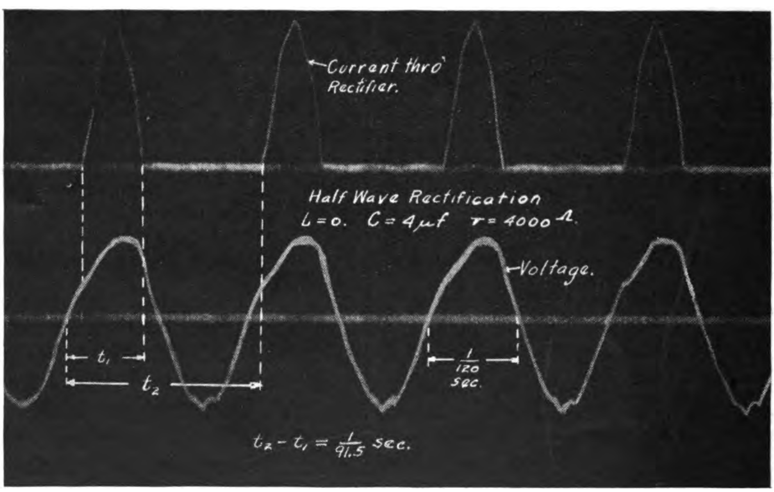

FIG. 4 (*b*).

The double wave rectifier, in its behaviour, is similar in every respect to that described for the half-wave rectifier with the exception that, since the condenser is charged and discharged twice rather than once during a cycle

of the applied voltage, the fundamental frequency of the alternating component of the condenser voltage will have twice the frequency of the applied voltage; furthermore, as the time of condenser discharge is shorter, the

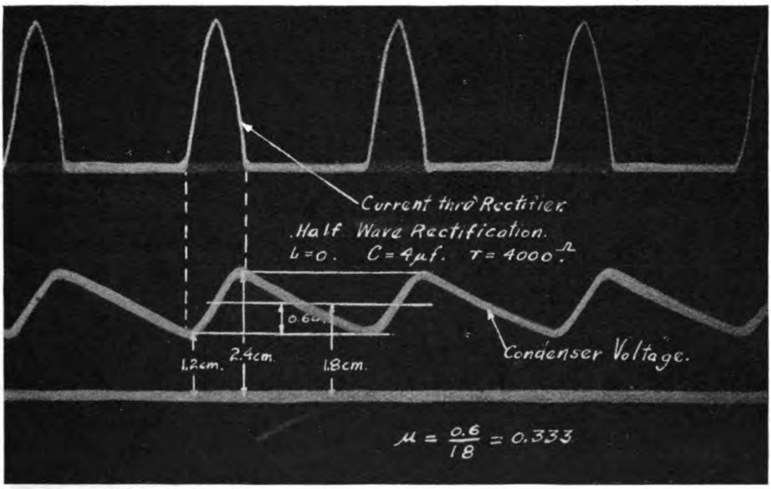

FIG. 4 (*c*).

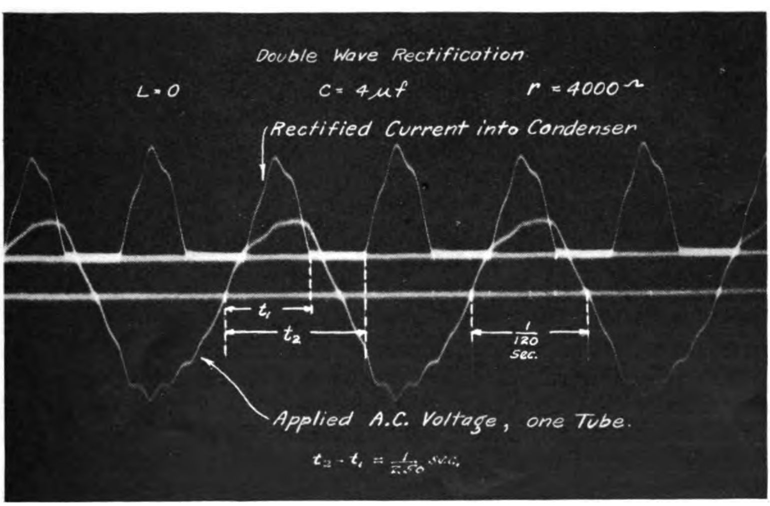

FIG. 5 (*a*).

amplitude of the alternating component will be less than with half-wave rectification. These features have an important bearing upon the design and operation of the apparatus.

The action of the rectifier circuit has been investigated with assistance of an oscillograph, a large number of oscillograms being obtained with different conditions of loading and power output. Those shown in Figs. 4 and 5 are believed to be typical of the extreme conditions which will be met with in practice and which will permit of satisfactory telephonic operation.

The explanation of the action of the rectifying circuit has been made to depend upon values of V_0, the voltage consumed within the tube, and the time interval $t_2 - t_1$. The former quantity is a function of the internal tube resistance, of the current through the tube and of the type of load; the time, $t_2 - t_1$, since saturation condition is never obtained, is determined largely in value by the characteristics of the load. The two quantities are seen to be interdependent, a change in one involving a change in the other.

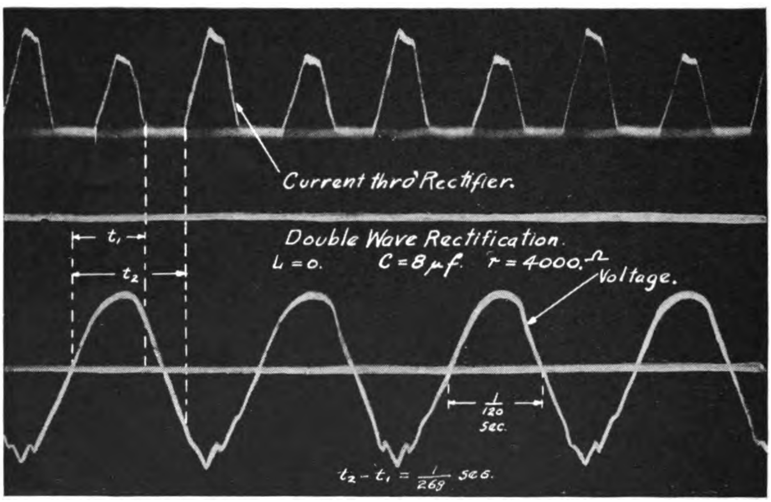

FIG. 5 (*b*).

It is difficult to estimate and practically impossible to compute with any accuracy, the probable values of V_0 and $t_2 - t_1$. A direct measurement of the same may also be made only with difficulty, and in the case of the voltage drop V_0, only in an indirect method. Consideration of the circuit diagram will show that a voltmeter of the ordinary type may not be employed directly since for that portion of the cycle during which the tube is supposed to offer an infinite resistance, it would be shunted by a finite and comparatively low resistance, *i.e.*, that of the voltmeter. The readings of the latter would therefore not indicate the true values of the tube voltage, in fact would alter the entire operation of the circuit. The oscillograph was employed to study and measure the variations of these two quantities, under various conditions of loading and applied voltages. The time, $t_2 - t_1$, was measured directly from the oscillogram by comparison of the current

and voltage waves, of which the frequency of the latter was known; the voltage V_0, was measured by calibrating the oscillograph in terms of voltage and noting the difference between the maximum applied voltage, E_0, and the maximum voltage V_c developed over the capacity. Elsewhere in this paper it is shown, that from the value of the R.M.S. or effective tube current which flows under load conditions a fairly accurate estimate of the voltage V_0 may be obtained, from the D.C. plate current—plate voltage characteristic cf the rectifier tube.

Based on the theory, as developed herein, the following design equations have been worked out.

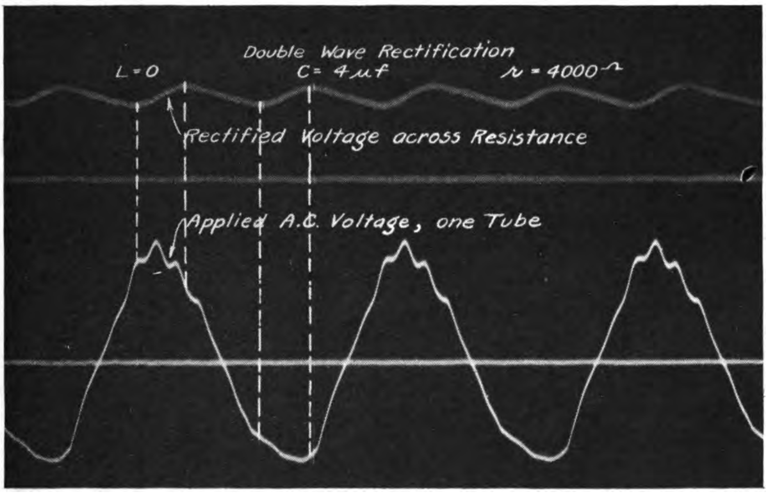

FIG. 5 (c).

Amplitude of Rectified Voltage.—Let E_0, V_0 and V_c represent respectively the *maximum* values of the applied voltage, maximum voltage consumed within the tube and condenser voltage, as shown in Figs. 2 and 3; then when the steady state has been obtained,

$$V_c = E_0 - V_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where V_c is the value which obtains when $t = t_1$. When $t = t_2$, V_c has decreased in value to V_c' where

$$V_c' = (E_0 - V_0) \, . \, K \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which

$$K = \epsilon^{-\frac{t_2 - t_1}{rC}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

ϵ being the base of Naperian logarithms.*

* **Steinmetz**, "Transient Electric Phenomena and Oscillations" (*McGraw-Hill Publishing Co., Ltd.*), Chapter V.

For large values of r, or for $r = \infty$ $K = 1$; however for large values of r the current passing through the tube is very small and hence the voltage consumed therein may, for all practical purposes, be neglected. The condenser voltage, therefore, will be approximately equal to the maximum value of the applied A.C. voltage or

$$V_c' \Big|_{r=\infty} \simeq E_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The decrease in condenser voltage, ΔV_c, is given by

$$\Delta V_c = V_c - V_c' = (E_0 - V_0)(1 - K) \quad . \quad . \quad . \quad . \quad . \quad (5)$$

As noted previously, the average value, V_{dc}, of the condenser voltage is very approximately equal to the arithmetical mean of V_c and V_c', or

$$V_{dc} = V_c - \frac{\Delta V_c}{2} \quad .$$

$$= (E_0 - V_0)\frac{1 + K}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Equation (6) is fundamental, giving the average value of the rectified voltage as a function of the maximum applied voltage, voltage drop within the tube and the constants of the circuit. By transposition it may be rewritten in the form

$$E_{\text{eff.}} = \frac{\sqrt{2}}{1 + K} V_{dc} + \frac{V_0}{\sqrt{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

from which, for known values of K and V_0, as determined by the characteristics of the complete load circuit and by the type of rectifier tube to be employed, the effective or R.M.S. value of applied voltage may be computed as a function of the required values of the rectified voltage V_{dc}. For *half*-wave rectification, the voltage given by equation (7) is that of the *full* transformer secondary; for *double* wave rectification it is *one-half* of the transformer secondary voltage.

The effect of ignoring the voltage drop within the tube is apparent from equations (6) and (7), resulting in a value of rectified voltage higher than is actually obtained in one case, and in an effective value of applied voltage lower than is actually obtained in the other.

If an inductance L is included in series with final load resistance r, certain of the equations as written require modification. Equation (3) is changed into the form *

$$K' = \frac{1}{2S}\left[(r + S)\epsilon^{-\frac{r - S}{2L}(t_2 - t_1)} - (r - S)\epsilon^{-\frac{r + S}{2L}(t_2 - t_1)}\right] \quad . \quad . \quad . \quad (8)$$

in which

$$S = \sqrt{r^2 - \frac{4L}{C}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

For values of r and C not too small and of L not too large, the last term of

* **Steinmetz**, *loc. cit.*

equation (8) will be very small compared to the first and may be neglected; equation (8) may then be rewritten,

$$K' \cong \frac{r+S}{2S} \epsilon^{-\frac{r-S}{2L}(t_2-t_1)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Values of K' so obtained are substituted directly for K in equations (6) and (7).

(*To be concluded.*)

A Method of Measuring Coil Capacities and Standardising Wavemeters.*

By GREGORY BREIT.

The method to be described in this note is a method of adjusting the frequencies of two alternating currents accurately to a ratio which is known. It may be used for the measurement of capacities of inductance coils and for standardising the wavemeters used in radio communication, because in both of these an accurate knowledge of frequencies is required.

Description of Phenomenon Used.

It is often observed that if a detector is placed in the neighbourhood of two radio-frequency electron tube generating sets a musical note is heard in a pair of telephone receivers connected in the detector output even if the frequencies of the two generating sets are not near equality. A measurement of the frequencies of both generating sets reveals the fact that if the note is heard the ratio of the frequencies is very nearly that of two small whole numbers.

Explanation of Phenomenon Used.

The reason which makes the musical note appear when the two frequencies are nearly in the ratio of two small whole numbers is the distortion in the current of the detector circuit caused by the rectifying properties of the detector, and at times the distortion of the waveform of the oscillator itself.

If there were no distortion each generating set would cause a current in the detector circuit and an E.M.F. across its terminals which would be very closely sine functions of the time. The rectifying properties of the detector change the current into a periodic current of the same period as that of the generating set which, however, is no longer a sine function of the time.

This function is finite, single valued, and continuous, and in a finite interval it has a finite number of maxima and minima. It is periodic. Therefore, it may be represented by a Fourier series. The consecutive terms of the Fourier series are sine functions of the time. Their frequencies are integral multiples of the frequencies of the fundamental.

* Received July 25th, 1921, and published by permission of the Director of the Bureau of Standards, Washington, U.S.A.

If the fundamental frequency of the first generating set is f_1 then according to the above the E.M.F. across the detector terminals is the sum of a finite or infinite number of E.M.F.'s whose frequencies are f_1, $2f_1$, $3f_1$, $4f_1$, etc. Similarly if the fundamental frequency of the second set is f_2 then the E.M.F. across the detector terminals is the sum of E.M.F.'s of frequencies f_2, $2f_2$, $3f_2$, $4f_2$ . . .

Now generally if E.M.F.'s of two frequencies f_1, f_2 are impressed on the grid of an electron tube, the output current contains terms of the type

$$[a_1 \cos(2\pi f_1 t - \epsilon_1) + b_1 \cos(2\pi f_2 t - \epsilon_2)]^m$$

where m is an integer, because the output current may be expanded by Taylor's series in terms of the input voltage.

The term of perhaps the largest practical importance in many cases is that corresponding to $m = 2$. The expansion of that term is

$$a_1^2 \cos^2(2\pi f_1 t - \epsilon_1) + b_1^2 \cos^2(2\pi f_2 t - \epsilon_2) + \\ + 2a_1 b_1 \cos(2\pi f_1 t - \epsilon_1) \cos(2\pi f_2 t - \epsilon_2).$$

The last term in this expansion is

$$a_1 b_1 [\cos(2\pi(f_1 + f_2)t - \epsilon_1 - \epsilon_2) + \cos(2\pi(f_1 - f_2)t - \epsilon_1 + \epsilon_2)].$$

Hence the output contains a term of frequency $(f_1 - f_2)$, *i.e.*, the beat note of acoustics.

This same fact may be illustrated graphically. Thus if the E.M.F. of frequency f_1 is as shown in Fig. 1, and if the E.M.F. of frequency f_2 is as shown in Fig. 2, the sum of the two E.M.F.'s is as in Fig. 3. When the E.M.F. is rectified in the detector the current has the appearance shown in Fig. 4, which in the telephone has the effect of pulsating current shown in Fig. 5. The frequency of this is the difference in the frequencies of f_1 and f_2. If f_1 and f_2 are close together, $f_1 - f_2$ may be so low as to give an audible note in a pair of telephones. Hence, when the detector is influenced by the two generating sets of frequencies f_1, f_2 its output contains currents of frequencies $mf_1 - nf_2$ where m, n are integers, because mf_1, nf_2 are harmonics of f_1 and f_2 and are present in the circuit on account of distortion.

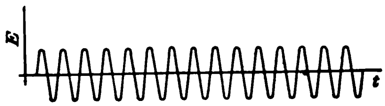

FIG. 1.

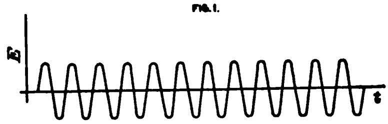

FIG. 2.

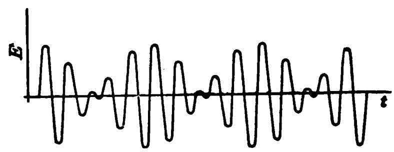

FIG. 3.

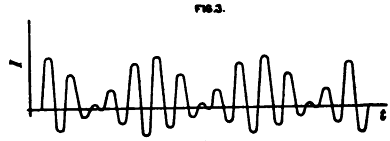

FIG. 4.

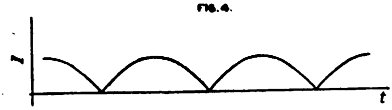

FIG. 5.

If any one of these currents is of a sufficiently low frequency and if it is present in sufficient quantity a note will be heard in the telephones. If the

frequency of one of the sets, say, f_1 be varied, the pitch of the note will be changed. When

$$mf_1 - nf_2 = 0 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

the pitch of the note becomes zero. Thus as f_1 is varied a region is covered in which a note is heard and in the middle of which the note is lost because its frequency vanishes. The silent region in practice is very narrow and either edge of it may be taken to give a value of f_1 such that (1) is true.

If the silent region is not sufficiently narrow a setting may be usually made on either side of the silent region at points giving notes of equal pitch. The frequency of these settings differs from the value of f_1 corresponding to (1) by the pitch of the note heard. The adjustment to equal pitch can be made very precise by comparing it with the pitch of a fixed frequency, which may conveniently be produced by an electron tube generating set. The comparison can be made by beats, either acoustically or else by coupling very loosely the fixed audio-frequency generating set to the same amplifier which is used in amplifying the sound produced in the detector.

To summarise—the centres of the silent regions are frequencies such that their ratio to the frequency of generating set No. 2 (giving frequency f_2) is the ratio of two whole numbers.

Determination of the Numbers m and n.

With the arrangement described so far, difficulty may be experienced in determining the numbers m and n unless one takes care to couple one generating set very much more closely to the detector than the other.

If this is done the waveform of the loosely coupled generating set, say the waveform of f_2, is distorted comparatively little. As a result the only frequencies of importance across the detector terminals are

$$f_1, 2f_1, 3f_1, 4f_1 \; . \; . \; . \; nf_1 \; . \; . \; . \text{ and } f_2.$$

The silent regions of the consecutive musical zones are then such that

$$\begin{aligned} f_1 &= f_2 \\ 2f_1 &= f_2 \\ 3f_1 &= f_2 \\ &. \; . \; . \end{aligned}$$

Consequently if the frequency f_2 is kept unchanged and the frequency f_1 is varied and adjusted to the successive silent regions, then f_1 takes consecutively the values

$$f_2, \frac{f_2}{2}, \frac{f_2}{3} \quad . \; . \; .$$

[Letting $\lambda = \frac{c}{f}$ where c is the velocity of light, the wavelength λ takes values λ_2, $2\lambda_2$, $3\lambda_2$ . . . .]

If the sensibility of the detector be sufficiently high, weak sounds will be heard between the strong sounds just mentioned. These correspond to

beats between harmonics of f_2 and harmonics of f_1. The difference of intensity between the beats given by the fundamental of f_2 and by its harmonics is so high, however, that there is no longer any possibility of confusing the two. When the frequencies $f_2, \frac{f_2}{2}, \frac{f_2}{3}, \frac{f_2}{4} \ldots$ have been located there is no difficulty in estimating the particular harmonic of f_2, for a weak sound by the variations required in the condenser of the generating set No. 2 in order to produce a given change in pitch. A numerical example of this will be given later.

The setting of generating set No. 1 which gives $\lambda_1 = \lambda_2$ is determined by bringing a circuit into resonance with the frequencies generated in both sets. Since only very loose coupling of generating set No. 2 to the detector is required any changes in generating set No. 1 do not react on generating set No. 2. Its frequency is thus constant during the experiments unless there is some unsteadiness in the set due to mechanical vibrations, unsteady batteries, temperature changes, etc. In practice generating set No. 2 is kept in a metal screened cage so as to eliminate capacity effects of the observer's body. No direct connection to the detector is made. The induction which is obtained when a wire from the detector is stretched into the cage through a hole is sufficient to give audible beats corresponding to very high harmonics of f_1.

The constancy of f_2 during the experiment is proved by the consistency of the experimental results for different values of f_2.

Experimental Arrangements.

The generating sets No. 1 and No. 2 are electron tube generating sets. Generating set No. 2 is kept completely shielded and generating set No. 1 is kept as completely shielded as possible. The tubes used are Western Electric transmitting tubes (Type E). The two generating sets are coupled to the detector circuit. One is coupled by a wire from the grid of the detector tube, which is brought near to one generating set. The other generating set is coupled by means of condensers to the detector circuit. This coupling is very strong and makes the detector tubes operate under abnormal conditions giving high distortion.

The detector used consists of one or two electron tubes connected in parallel. Since high distortion is necessary, these tubes are connected across the tuning condenser of generating set No. 1, in series with two condensers. The connection is shown on Fig. 6. Here C_t is the tuning condenser of generating set No. 1; C_1 and C_2 are the two coupling condensers; F, G, and P are the filament, grid, and plate of the tube. The tube used is

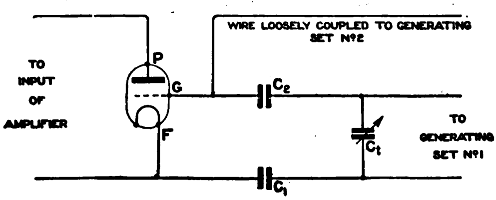

FIG. 6.—Diagram of Connections used for Distorting Radio Frequency by means of an Electron Tube.

the Western Electric receiving tube—Type J (VT—1). The tube is used without any plate battery, for it is found that no improvement in its operation is caused by the use of a plate battery under the conditions described. The action of the detector tubes without plate battery under these conditions is not at all surprising because the voltage of the grid is so high that the electrons acquire sufficient velocity on reaching the grid to pass, by inertia, to the plate.

The output terminals of the tube, *i.e.*, the terminals F, P, are connected to the primary of a transformer the secondary of which is connected across the input tube of a two-stage audio-frequency amplifier. It was found convenient to shield the amplifier from the rest of the apparatus by putting it in an iron box. This eliminated oscillations in the amplifier. The condensers C_1 and C_2 may be varied so as to give the most satisfactory operation. Frequently both of them may be large—say 0·02 microfarad.

Under such conditions beats between the 105th harmonic of f_1 and the fundamental of f_2 could be heard distinctly. Beats with the second harmonic of f_2 could be followed up to the value of $\frac{f_1}{f_2} = 95$. If the second harmonic of f_2 were considered as the frequency of comparison 191 equal wavelength intervals could be laid off by that method because the fundamental gives 95 intervals, each of which is divided into two by the harmonic and in addition the harmonic gives one more interval. The wavelength λ_2 in this case was about 20 metres.

Application to Standardising Wavemeters.

Suppose the reading of a wavemeter to be calibrated to have been compared with the reading of a standard wavemeter for some one frequency by any method.* This means that the frequency at which the comparison was made can be measured correctly by the wavemeter, whatever its nature may be. Call this frequency f_0. By means of the wavemeter, set the generating set No. 1 to a position where it emits f_0. By listening, adjust f_2 until f_0 is in the silent region of a musical zone. Then keep f_2 fixed, and vary f_1 both increasing and decreasing it. As explained above $f_2 = nf_0$ where n is a whole number. The frequencies obtained by adjusting f_1 to the consecutive silent regions are then

$$nf_0, \quad \frac{nf_0}{2}, \ldots, \frac{nf_0}{n-1}, \quad f_0, \quad \frac{n}{n+1}f_0, \ldots \frac{nf_0}{n+m} \ldots$$

The number n is easily determined by counting the number of musical zones between f_2 and f_0. If f_2 and f_0 are included this number is n.

In this manner, n and f_0 both being known, a number of known wavelengths is obtained for the calibration.

If f_0 is small f_2 may be adjusted to be equal to f_0 and the frequencies f_0, $2f_0$, $3f_0$ . . . may be measured.

* The wavelength may be ascertained either by means of the "multi-vibrateur" (see H. Abraham and E. Bloch, *Annales de Physique*, 12, 237—302, October, 1919), or by means of a method which the author expects to describe in a future communication.

Application to Measurement of Coil Capacities.

By definition, if there are such constants C_0, L that

$$L(C + C_0) = \frac{1}{\omega^2}$$

where C is the capacity which must be connected across the coil terminals in order to give resonance with a frequency $\frac{\omega}{2\pi}$, then L is called the pure inductance of the coil and C_0 is termed its effective capacity. Hence if f_1, f_2 be values of the frequency f corresponding to two values C_1, C_2 of the capacity C it must be true that

$$\frac{C_1 + C_0}{C_2 + C_0} = \frac{f_2^2}{f_1^2}.$$

By the method described f_2/f_1 is adjusted to

1, 2, 3, 4 . . .

consecutively. Hence if on tuning to these wavelengths values of C equal to C_1, C_2 . . . are obtained then

$$\frac{C_1 + C_0}{1^2} = \frac{C_2 + C_0}{2^2} = \frac{C_3 + C_0}{3^2} = \ldots \frac{C_n + C_0}{n^2} = \ldots$$

This set of equations suffices to determine C_0 if it exists, *i.e.*, if a number C_0 may be found so as to satisfy the above set of equations.

As an example consider the following measurement which gave for the consecutive values of C

$$C_3 = 139\ \mu\mu\text{F}$$
$$C_4 = 263\ \mu\mu\text{F}$$
$$C_5 = 424\ \mu\mu\text{F}$$
$$C_6 = 622\ \mu\mu\text{F}$$
$$C_7 = 856\ \mu\mu\text{F}.$$

In the following table, the values of $\frac{C_n + C_0}{n^2}$ are tabulated for various values of n and C_0.

Trial value of C_0	20	21	22	23
$\frac{C_3 + C_0}{3^2}$	1·766	1·781	1·788	1·801
$\frac{C_4 + C_0}{4^2}$	1·769	1·776	1·781	1·787
$\frac{C_5 + C_0}{5^2}$	1·776	1·780	1·784	1·788
$\frac{C_6 + C_0}{6^2}$	1·782	1·786	1·788	1·791
$\frac{C_7 + C_0}{7^2}$	1·787	1·790	1·793	1·793

If C_0 is taken as 22 micromicrofarads, the values of $\frac{C_n + C_0}{n^2}$ are most consistent. Since the capacities C_n used in the work are calibrated only with an accuracy of 1 $\mu\mu$F, C_0 may be taken to be 22 $\mu\mu$F.

For the same coil a silent region was obtained also for $C = 197$ $\mu\mu$F. This corresponds to the ratio between the frequencies being $3\frac{1}{2} = \frac{7}{2}$. And in fact

$$\frac{197 + 22}{\left(\frac{7}{2}\right)^2} = 1{\cdot}79.$$

Also the capacities 177, 167, 158 were obtained for weak sound zones. The ratio of f_1/f_2 for these can be obtained easily by writing the capacities in order, viz.

139, 158, 167, 177, 197.

The first (139) corresponds to $\frac{f_1}{f_2} = 3$.

The last (197) corresponds to $\frac{f_1}{f_2} = \frac{7}{2}$.

The differences between consecutive numbers of the above set of numbers are 19, 9, 10, 20. Thus 167 is in the middle of the interval and corresponds to beats between the fourth harmonic of f_2 and an appropriate harmonic of f_1 which is readily seen (by a method to be described later) to be the 13th. The number 158 corresponds to beats between the 6th harmonic of f_2 and the 19th of f_1. The number 177 corresponds to beats between the third harmonic of f_2 and the 10th of f_1. Thus the following table is obtained :—

$C_n =$	139	158	167	177	197
$n = \frac{f_1}{f_2} =$	3	$\frac{19}{6}$	$\frac{13}{4}$	$\frac{10}{3}$	$\frac{7}{2}$
$\frac{C_n + C_0}{n^2} =$	1·79	1·79	1·79	1·79	1·79

This table illustrates that when many weak sound zones are heard the exact ratio of the frequencies may be easily determined once the strong zones have been located. The simplest rule to follow in such a case is to look at the distances of the capacity settings as proportional to corresponding wave-

lengths if these distances are small. Thus in the above instance the interval from 139 $\mu\mu$F to 197 $\mu\mu$F may be regarded as divided into four parts. 158 occupies a position at $\frac{1}{3}$ the length of the interval to the right. Its wavelength is then

$$\left\{3 + \frac{1}{3}\left(\frac{7}{2} - 3\right)\right\}\lambda_2 = \frac{19}{6}\lambda_2.$$

Similarly the other ratios may be found.

It is often convenient to plot n^2 against C_n. If C_0 exists this gives a straight line. The negative of the intercept of the straight line on the axis of C_n gives C_0. Such a graph is shown in Fig. 7.

In distinguishing between beats with the fundamental of f_2 and those with harmonics of f_2 use can be made of the fact that the width of the musical zone for the harmonics is very much smaller than that for the fundamental. It is likely that by the use of beats with harmonics of f_1 an increase in the

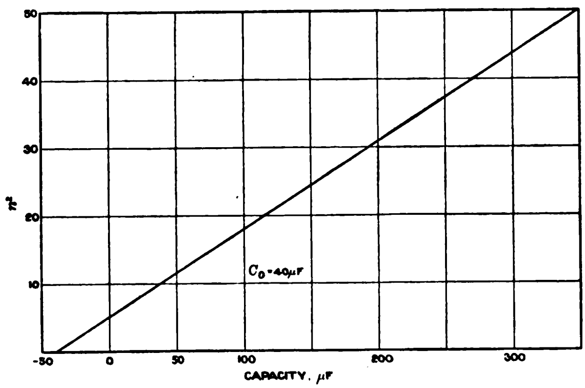

FIG. 7.—Graphical method of computing C_0.

sensibility of the method proposed by Whiddington * for the measurement of small lengths could be made. The desirability of having such an increase is, however, questionable.

The method described is capable of adjusting frequencies to 1 part in 10^6 if these frequencies are of the order of 10^6. It thus far exceeds the ordinary requirements. It has the advantage of keeping the temporary standard of frequency (or wavelength) caged and thus unaffected by motions of surrounding objects. Coupling to the reference standard is avoided which contributes to its permanence. Also, too close coupling to the variable generating set can be detected because if the coupling is too close a note of variable pitch is heard when the coupled coil is tuned. The method is best suited for standardisation of short wavelengths because of its increased accuracy at such wavelengths.

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* See *Wireless World*, 8, p. 739, January 22nd, 1921.

As a matter of fact, in precise work it was found necessary to use an electron tube as an indicator of resonance because less sensitive indicators required too close coupling, and it was also found necessary to use very careful shielding, both of the wavemeter and of the generating set system. It was found possible, however, to use the method with ordinary commercial wavemeters equipped with hot-wire ammeters or thermogalvanometers even though on tuning these wavemeters the wavelength of the generating set changed sufficiently to give a whine in the telephone receivers. This was made possible by the fact that the change in the wavelength of the generating set becomes very small when the wavemeter is exactly in resonance, so that it is possible by adjusting both the wavemeter and the generating set to make the wavemeter read a maximum when the generating set is in good adjustment.

It is also helpful at times not to use the wavemeter by adjusting to a maximum of current, but to use it by adjusting to equal settings on both sides of the maximum. In such a case the same accuracy may be obtained with very much looser coupling. Also, reading the indicator instrument by means of a magnifying glass is helpful.

Summary.

A method has been worked out for the adjustment of two frequencies to an accurately known ratio.

The method is based on the fact that an electron tube detector distorts the waveform of the E.M.F. impressed on it and thus produces harmonics of that E.M.F. in its output.

The harmonics produced by a circuit of adjustable frequency are made to give beats with the fundamental of a circuit of fixed frequency. The beats are rectified in an amplifier and are heard as a musical note.

When the beat frequency is zero the ratio of the frequencies is exactly a whole number. This whole number may be made very large as, *e.g.*, 100.

Applications of the method to frequency (wavelength) standardisation and to coil capacity measurements have been described.

It is the author's pleasant duty to express here his gratitude to Dr. J. H. Dellinger, Dr. J. M. Miller, Messrs. L. E. Whittemore, R. T. Cox, C. T. Zahn, and R. S. Ould, for reading the manuscript.

Bureau of Standards,
Washington, D.C., U.S.A.

Some New Laboratory Apparatus for Radio Measurements.

At the recent exhibition of the Physical Society of London (for brief description of which see page 99), some interesting apparatus was exhibited by Messrs. H. W. Sullivan, including a Radio Frequency Bridge, and a Standard Heterodyne Wavemeter.

SCREENED RADIO FREQUENCY WHEATSTONE BRIDGE.

This instrument is designed for the measurement of resistance, capacity and inductance at radio frequencies. One of its chief advantages is the employment of a high-frequency generator in place of the buzzer apparatus which has hitherto been used for determinations of this character. The advantages of using a high-frequency oscillator are obvious as it enables tests to be carried out under actual working conditions. The range of

FIG. 1.

frequencies of this oscillator is between 10,000 and 500,000 ~, the higher frequency representing a wavelength of 600 metres. This set is one of the first of its kind available for practical testing purposes, and it will probably fill a long-felt want for the easy and accurate measurement of radio-frequency constants. The instrument (Fig. 1) is fitted with a vacuum thermo-galvanometer reading from 1 to 10 milliamperes. As may be seen from the circuit diagram (Fig. 2), the bridge arms comprise non-inductive resistance ratio arms, and also a non-inductive resistance in the third bridge arm. The resistances in this third, or rheostat arm, are controlled by two dials having

the following values :—First dial 0 to 10 ohms in steps of 1 ohm ; second dial 0 to 1 ohm in steps of 0·1 ohm. Additional resistances of 10, 20 and 30 ohms can also be inserted in this arm. All the resistances used in these arms have no measurable inductance or capacity.

It is claimed that an accuracy of measurement within 1 to 2 per cent. is possible at the higher ranges and from 0·5 to 1 per cent. at the lower ranges of the instrument.

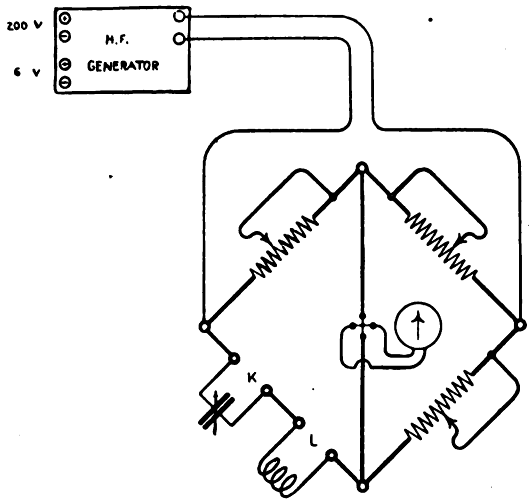

FIG. 2.

When this bridge is used in conjunction with a valve oscillator to generate the necessary radio-frequency currents and with standardised and calibrated air condensers and variometers, the following measurements can be carried out :—

(*a*) Effective resistance of condensers and inductances, and their capacity and inductance values at all frequencies between 10,000 and 500,000 cycles per second.
(*b*) Effective resistance, capacity and inductance of antenna systems and other radio-frequency circuits.
(*c*) Dielectric tests of cables and lines.

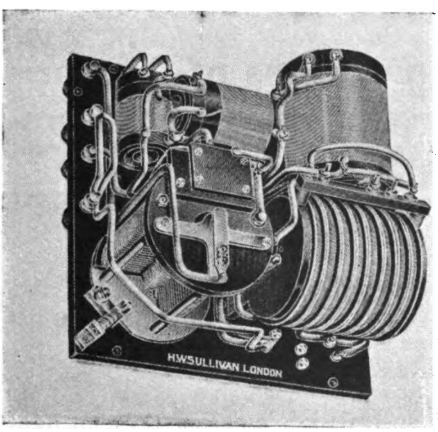

FIG. 3.

As may be seen from the circuit arrangement shown in Fig. 2, terminals are provided in the fourth arm of the bridge for the insertion of a condenser K and an inductance L. These two must be brought into resonance with the supply frequency so that the arm behaves as a non-inductive resistance, which can be balanced against the rheostat arm of the bridge. Either the condenser or the inductance can, of course, be replaced by the apparatus under test, depending upon whether it has a capacitive or an inductive reactance.

Universal Laboratory Standard Heterodyne Wavemeter.

The range of this instrument is from 150 to 20,000 metres. Its external appearance may be seen from Fig. 4. The interior arrangement of the instrument is shown in Fig. 3, from which illustration the arrangements of the coils and condensers can be seen. The variable air condenser has a fine adjustment for accuracy in tuning, and a special type of electro-magnetic interrupter is included for the production of interrupted continuous waves for spark adjustments. The only external apparatus necessary is a 6-volt accumulator and a 50-volt battery for the high tension supply, terminals being provided for telephones for use when necessary.

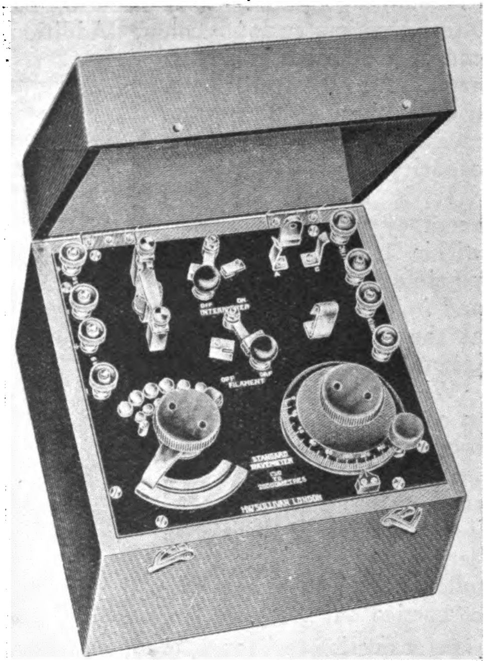

Fig. 4.

Notes on the Technical Decisions of the Paris International Conference on Radio Communications (June—August, 1921).

By Professor G. VALLAURI.

(*Continued from page* 25.)

Characteristics of R.T. Stations and of their Emissions—Nominal Range.

According to the definitions adopted an emission is designated, not only by the type of the wave but also by the mean wavelength (or mean frequency)

and by the equivalent decrement (or by the class). The determination of the mean wavelength and of the particular wavelengths (or frequencies) taken as abscissæ of the resonance curve, requires the existence of a standard of wavelength as well as a means of calibrating wavemeters. It is of evident importance with the object of reducing to the minimum the interferences and of utilising completely the series of wavelengths (or frequencies) which are available, that the measurements of them be made with the greatest possible precision and that advantage should be taken of every advance made in technology in order to reduce to the minimum the tolerances (limits of error). As a basis for the calibration of wavemeters one requires a method of absolute measurement of the frequencies, and it is that which has been indicated by the Paris Committee, which has also cited as an example of one of such methods that of the multivibrator of Abraham and Bloch.

But it is not sufficient to consider the case of an emission authorised upon a certain wavelength and for which it may be assumed that the mean wavelength of the resonance curve corresponds with sufficient exactness to the indicated value. There must also be considered the case in which to a given district, or to a given service or to a given station there may be attributed not a single wavelength but in fact a series or band of wavelengths. In this case the emissions ought to be made upon mean wavelengths sufficiently distant from the limits of the series in such a way as not to give rise to excessive interference to the detriment of the services that adopt the adjacent series. Here also the Committee has not believed that it has sufficient data for fixing, up to the present, precise regulations.

With regard to the antennæ, to put in force the recent advances attained in the technique of the measurements of radiation and to contribute to their ulterior development the Committee has settled that there must be given in the new edition of the particulars of fixed land stations indications relative to the type of antenna, to the electrostatic capacity, to the natural wavelength, to the radiation height, to the type of generating apparatus, and to the normal intensity of antenna current.

The discussion of some definition of the *range* of a R.T. emission merited particular attention. It is well known that such an element cannot be defined in an absolute way because it depends in its turn on other elements actually independent of the transmitting station such as (1) the continually changing physical conditions of the space in which the propagation takes place, (2) the characteristics of the antenna and of the other apparatus used by the receiving station. For these reasons it is only possible to speak of a *nominal range*.

Because it is possible to-day to evaluate with sufficient approximation the power radiated from an antenna the definition of nominal range requires (1) the adoption of a *formula of propagation*, (2) the fixation of a limiting value for the intensity of the *electromagnetic* field necessary for reception. There are available now for formulæ of propagation only semi-empirical relations and amongst these that which seems provisionally most acceptable, at least for small and medium distances, is the well-known Austin-Cohen

formula to which may be given the following form (neglecting the effects of the curvature of the earth) :—

$$hI = \frac{10^{-6}}{377} E\lambda d\epsilon^{0 \cdot 000048d/\sqrt{\lambda}}$$

where h = the radiation height of the transmitting antenna in metres
I = the intensity of current at the base of the transmitting antenna in amperes
E = the vertical electric field produced at the distance d in μV/m
λ = the wavelength in metres
d = the distance in metres.

As to the choice of the intensity of field necessary for reception, the Committee has at first considered only the small stations, coastal and movable, for which ultimately the definition of range is particularly important in relation to the rules for signals for help. For such services which still operate normally with apparatus with damped waves the Committee has deemed it opportune to assume for the calculation of the range the value $E = 150\ \mu$V/m.

But as appears from the formula the calculation of the range requires also the knowledge of the height of radiation h and this is obtained* by measuring at small distances (between 1 and 10 wavelengths approximately) the electric field or the magnetic field and applying the same formula now referred to in which the exponential factor may in such a case be identified with unity. This measurement of h may however turn out to be a little laborious and therefore the Committee has indicated alternatively as a first approximation and only in the case of ship stations the possibility of deducing the height of radiation from the total antenna height (height with reference to the surface of the sea of the highest point of the antenna), multiplying this last by an empirical coefficient which is assumed equal to 0·55.

TABLE III.

Wave		Height of Antenna × Antenna Current = hI (m × A).				
Frequency, kilocycles.	Length, m.	Distance, km 100	150	200	250	300
667	450	22	38	56	87	105
500	600	29	47	70	100	130
375	800	38	61	89	121	157

As an example of the application of the Austin-Cohen formula Table III. may be referred to which expresses the values of the product hI expressed in metre-amperes for the distances and for the wavelengths which are of interest with regard to signals of distress ($E = 150\ \mu$V/m).

The Committee has not relied in any way on establishing exclusively a

* *L'Elettrotecnica*, 8, p. 213, April 5th, 1921, and Publication No. 11 of the E. and R. T. Institute.

preference for this method of *calculating* the range of coast-line and movable stations, but has left each administration free either to adopt such a method of calculation, or to verify the range of the stations by means of direct practical tests of the daily communications.*

The Committee has been yet more cautious in the treatment of the range of the large stations. Any indication in the "particulars of the station" has not only been considered optional but for the most part may have two different values, for each emission. Of this the Committee has not given any explanation, but in reality the two values will correspond, the one to the "ordinary range," the other to the "safe range," that, namely, which can be relied upon even in unfavourable conditions; yet excluding those excep-

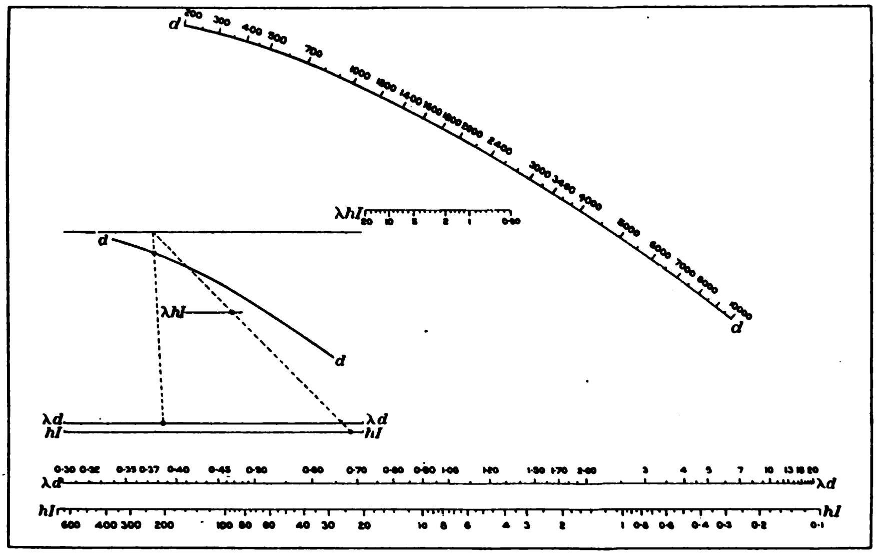

FIG. 3.

tionally unfavourable. In the case of emissions with continuous waves manipulated or modulated (types A_1 and A_2) the ordinary range should be calculated with $E = 10\,\mu\mathrm{V/m}$ and the safe range with $E = 50\,\mu\mathrm{V/m}$. In the case of radiotelephonic emissions and of those with damped waves (types A_3 and B) there should be used respectively the values 50 and 250 $\mu\mathrm{V/m}$.

The value of E being fixed and the product hI being considered as a single variable the formula of propagation becomes a relation between the three variables hI, d and λ, that can be represented graphically in the most varied ways with the aid of known graphical methods. For example in Fig. 3 is

* In the actual state of technical knowledge the practical tests appear indispensable in the case of the stations of dirigibles and aeroplanes, because the form of the waves produced by these and particularly the want of uniformity of the radiation in different directions does not permit of applying without doubt the formula of Austin-Cohen (*L'Elettrotecnica*, 8, p. 342, May 25th, 1921, and *Bollettino Radiotelegrafico*, 2, No. 15, p. 70).

set out a diagram with double curves from which one can deduce one of the three variables when the other two are given.* The method of using it is indicated at the left-hand side of the diagram. One perceives that the diagram contains two scales for λ; upon one of these λ_{hI} are taken the points of alinement with those of the scale hI, whereas on the other λ_d, are taken the points of alinement with those of the scale of d. The two alinements must intersect in a point on the ungraduated horizontal line which forms the top of the diagram in Fig. 3. Naturally for the use of the diagram may be substituted that of tables with two related columns, as for example the Tables IV. and V., of which the first gives the product hI as a function of d and λ, or the number of kilometre-amperes that it is necessary to have in the transmitting antenna in order to obtain a certain range with a certain wavelength; the second gives d as a function of hI and of λ, or the range that it is possible to attain with a certain number of kilometre-amperes in the transmitting antenna and with a certain wavelength. The tables and the diagram have been calculated by giving to the exponential factor the expression $0{\cdot}0015d/\sqrt{\lambda}$ and by expressing d and λ in kilometres. Besides it has been assumed $E = 50\,\mu$V/m. Naturally if results relative to $E = 10\,\mu$V/m or $E = 250\,\mu$V/m are wished for it is sufficient to divide or to multiply respectively by 5 the values of hI referred to (as has been done *e.g.* in Table V.) and analogously for any other value of E that it may be desired to assume.

The formula of propagation having been decided it is easy to calculate the most favourable wavelength, that is the one which makes hI a minimum for a certain distance; and there is obtained as is known the parabolic relation

$$\lambda_{(m)} = 562.10^{-6}d^2_{(km)}.$$

For evident practical reasons this relation cannot be adopted unreservedly as the rule for the selection of the wavelengths. Therefore the Committee before fixing a partial distribution of the various wavelengths has formulated the general rules: that generally the longer waves (the lower frequencies) should be used for the greater distances and the shorter waves for the smaller distances; that as a rule for distances less than 4,000 km there should not be used wavelengths beyond that of 12,000 metres, and for distances above 4,000 km wavelengths below 8,000 metres should not be used; that in general for distances above 1,500 km the wavelength employed, expressed in m, should not exceed three times the distance expressed in km.

Summarised, the data that in tabular form should be contained in the categories of data of fixed land stations are :—

(1) Name of the station.
(2) Call name.
(3) Administration on which the station depends.
(4) Administration or company that controls the station.

* The question of the conventional range has been exhaustively treated recently by the Institute E. and R. T. of the Royal Marine in a memoir prepared by the Inter-Allied Radiotechnical Committee which acted during the war. From this memoir are taken the diagram of Fig. 3 (constructed at the time by Professor G. Perci of the Royal Naval Academy) and the numerical tables referred to further on.

TABLE IV.—Value of hI in km $\times$ A as a function of d and λ.

Wavelength λ in m.	Distance d in km. 300	600	1,000	1,500	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	Wavelength λ in m.
300	0·027	0·124	0·617	3·64	19·05	442	9,090	—	—	—	—	—	—	300
600	0·043	0·153	0·542	2·18	7·67	79·5	737·3	—	—	—	—	—	—	600
1,000	0·063	0·196	0·595	1·89	5·33	35·9	214·1	1,196	—	—	—	—	—	1,000
1,500	0·099	0·249	0·677	1·87	4·61	23·5	107·1	455	1,860	—	—	—	—	1,500
2,000	0·110	0·301	0·767	1·95	4·42	19·2	73·7	267	922	—	—	—	—	2,000
3,000	0·153	0·402	0·948	2·19	4·50	16·1	50·9	151	431	1,196	—	—	—	3,000
4,000	0·200	0·499	1·125	2·45	4·76	15·1	42·7	112·5	287	710	1,713	—	—	4,000
5,000	0·244	0·595	1·301	2·73	5·08	14·9	38·8	94·8	336	509	1,134	—	—	5,000
6,000	0·287	0·691	1·471	3·00	5·42	15·1	36·9	85·1	188	406	856	1,775	—	6,000
7,000	0·330	0·785	1·639	3·26	5·79	15·3	35·9	78·9	167	344	695	1,376	—	7,000
8,000	0·374	0·879	1·806	3·53	6·15	15·6	35·4	75·4	154	305	590	1,134	—	8,000
10,000	0·459	1·062	2·133	4·06	6·84	16·5	35·4	71·0	137	357	472	856	1,525	10,000
12,000	0·544	1·241	2·459	4·58	7·58	17·5	36·0	69·5	129	231	407	706	1,207	12,000
14,000	0·629	1·419	2·778	5·08	8·29	18·6	37·0	69·1	124	215	368	617	1,021	14,000
16,000	0·713	1·596	3·088	5·60	8·96	19·6	38·0	69·1	121	205	341	558	903	16,000
18,000	0·795	1·773	3·404	6·09	9·68	20·7	39·3	69·9	120	199	324	519	819	18,000
20,000	0·878	1·949	3·718	6·57	10·37	21·8	40·6	71·0	120	194	311	490	758	20,000

TABLE V.—Value of d in km as a function of hI and λ.

hI (km × A) E=250 μV/m	1·0	2·5	5	10	20	35	50	100	200	350	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	ϵ=250 μV/m hI (km × A)
E= 50 μV/m	0·2	0·5	1	2	4	7	10	20	40	70	100	200	300	400	500	600	700	800	ϵ= 50 μV/m
E= 10 μV/m	0·04	0·1	0·2	0·4	0·8	1·4	2	4	8	14	20	40	60	80	100	120	140	160	ϵ= 10 μV/m
λ = 300 m	710	930	1,130	1,320	1,530	1,710	1,810	2,020	2,230	2,410	2,520	2,730	2,870	2,970	3,040	3,100	3,150	3,190	λ = 300 m.
600	660	930	1,200	1,460	1,740	1,970	2,110	2,400	2,700	2,960	3,100	3,400	3,500	3,720	3,820	3,900	3,970	4,030	600
1,000	600	930	1,220	1,520	1,870	2,130	2,320	2,680	3,070	3,400	3,570	3,940	4,200	4,360	4,480	4,580	4,680	4,760	1,000
1,500	520	870	1,180	1,530	1,920	2,250	2,460	2,890	3,330	3,720	3,930	4,420	4,710	4,900	5,070	5,200	5,310	5,400	1,500
2,000	450	800	1,130	1,520	1,940	2,320	2,550	3,030	3,530	3,960	4,220	4,750	5,090	5,320	5,500	5,650	5,770	5,880	2,000
3,000	370	700	1,040	1,450	1,900	2,330	2,600	3,180	3,780	4,310	4,620	5,260	5,650	5,920	6,130	6,320	6,470	6,600	3,000
4,000	300	600	930	1,370	1,870	2,320	2,610	3,260	3,930	4,530	4,870	5,590	6,040	6,360	6,610	6,810	6,980	7,130	4,000
5,000	230	520	850	1,280	1,800	2,280	2,600	3,290	4,030	4,680	5,050	5,860	6,370	6,710	7,000	7,200	7,400	7,570	5,000
6,000	190	480	780	1,200	1,730	2,240	2,580	3,310	4,080	4,790	5,200	6,060	6,600	6,960	7,270	7,500	7,720	7,900	6,000
7,000	—	430	730	1,130	1,660	2,180	2,540	3,320	4,140	4,900	5,320	6,220	6,810	7,220	7,560	7,810	8,030	8,210	7,000
8,000	—	380	660	1,070	1,600	2,130	2,480	3,300	4,160	4,930	5,390	6,360	6,970	7,380	7,730	8,010	8,260	8,460	8,000
10,000	—	320	570	960	1,490	2,000	2,360	3,250	4,200	5,020	5,510	6,570	7,250	7,710	8,080	8,380	8,650	8,880	10,000
12,000	—	270	500	860	1,380	1,910	2,300	3,180	4,160	5,030	5,550	6,710	7,460	7,960	8,370	8,700	8,980	9,230	12,000
14,000	—	—	460	800	1,290	1,820	2,200	3,100	4,100	5,040	5,590	6,840	7,620	8,150	8,580	8,950	9,250	9,500	14,000
16,000	—	—	420	730	1,200	1,730	2,130	3,030	4,060	5,030	5,630	6,920	7,750	8,300	8,770	9,160	9,480	9,750	16,000
18,000	—	—	390	680	1,130	1,660	2,040	2,960	4,020	5,020	5,640	6,990	7,850	8,450	8,920	9,320	9,660	9,930	18,000
20,000	—	—	340	630	1,060	1,560	1,940	2,870	3,970	5,010	5,630	7,050	7,940	8,540	9,050	9,460	9,820	10,100	20,000

(5)	Geographical position.	
(6)	Antenna	Type.
(7)		Electrostatic capacity in $m\mu F$.
(8)		Natural wavelength in m.
(9)		Height of radiation in m.
(10)		Type of the emission apparatus.
(11)	Wave	Type.
(12)		Class.
(13)		Frequency in kilocycles.
(14)		Length in m.
(15)	Normal intensity of the antenna current.	
(16)	Service	Nature.
(17)		Time table.
(18)	Range (optional)	($E = 250\ \mu V/m$). For the types B and A_3.
(19)		($E = 50\ \mu V/m$).
(20)		($E = 10\ \mu V/m$). For the types A_2 and A_1.
(21)	Habitual correspondents (name and geographical position).	

SCIENTIFIC RADIOTELEGRAPHY.

Broken up by the war as were the greater part of the international scientific organisations, many students felt the need of resuscitating them soon after the armistice, limiting them for the time being to the allied and associated nations of the Entente and to the neutral nations. There was therefore convoked in the summer of 1919 at Brussels the constituent assembly of the "International Council of Research," which fixed the chief arrangements of the new organisation that presupposes the constitution in each adherent country of a "National Council of Research." It will set about to collect and to co-ordinate the activities of the various "International Scientific Unions" (of astronomy, of geodesy and geophysics, of chemistry, of physics, of mathematics, of biological sciences, of geography, of geology, of bibliography and documentation, etc.) that should be in their turn sub-divided into various "National Committees." The seat of the International Council has been fixed at Brussels.

The effective functioning of this vast organisation has scarcely begun. Of the various international scientific unions some already possessed a concrete existence before the war and have been able therefore to revive more quickly their activity, such, *e.g.*, as that of geodesy and geophysics that is preparing to hold a general assembly at Rome in April, 1922. On the other hand other unions are scarcely in the embryo state, as, *e.g.*, the projected "International Technical Union," for which have been foreseen tasks in great number not excluding that of standardisation. Whenever such a union should succeed in actually constituting itself it would naturally not be able to neglect the existence of the International Electrotechnical Committee, that has already done a certain amount of work in the same field; and in every way would concern very closely our A.E.I. But up till now of the International Technical Union and of the work of its provisional committee (de Chardonnet, Fantoli, Otlet and G. L. Gerard) nothing more is known.

The "International Union of Scientific Radiotelegraphy" was provisionally constituted as continuation of an analogous international commission formed at Brussels in 1913 that has at disposal about 40,000 francs through a gift of Dr. R. Goldschmidt. To the union was also given a constitution that anticipates as a rule the existence of separate national committees (to be created on the initiative of the Government, or of the National Academy, or of the Council of Research or of other institutions or groups of similar institutions) the formation of commissions, the creation of an executive committee and of an administrative office or secretariat (at Brussels), the convocation of a general assembly every three years, etc. On the part of the financial administration, that must provide for the expenses of administration, of publication, of reduction and discussion of observations, not excluding eventually the remuneration of assistants, there should be drawn up a preliminary balance sheet, in which shall be fixed the annual unitary contribution. According as the population of the nations represented is inferior to 5, 10, 15, and 20 millions of inhabitants or superior to this last figure, the number of annual unitary contributions shall be respectively 1, 2, 3, 5, 8. It is laid down in any case that in this first period of the life of the union the annual unitary contribution must not exceed 200 francs. Moreover, whilst on questions of scientific order every delegate will dispose of one vote, in others the voting will be by nations and, according to the limits of population indicated, the number of the votes will be 1, 2, 3, 4, 5.

It is presumed that the first assembly of the U.R.S.I. (Union Radio-Scientifique Internationale) can take place at the same time as the world conference of electric communications prepared for by the meetings of Washington and of Paris. In view of this there were held, during this last meeting, some semi-official sittings, independent of the work of the committee, to formulate a programme of preliminary researches, the results of which will be able without doubt to furnish most useful data with the object of fixing at the next meeting a good programme of researches.

Amongst the R.T. questions of scientific interest, that by their nature are better adapted to an inquiry of international character, may be mentioned; the study of the laws that govern the transmission of energy in R.T. signals, atmospheric disturbances, interference produced by different transmissions and the means of eliminating it, R.T. measurements, electronic tubes, etc. In the meetings of Paris it was regarded as opportune to limit for the present the international agreements to the study of the two first questions.

The *law of the propagation of energy* has not yet been established on a completely and rigorously scientific basis, as has already been noted in treating of the conventional ranges. The study of this question covers the choice of the most convenient analytical formula, the determination of its constants, the examination of the continuous variations that the phenomenon of propagation undergoes and of the causes which produce them, the definition of the methods suitable for the measurement of the very feeble reception currents and of the electromagnetic fields that produce them, the establishment of the direction along which the propagation of energy takes place, etc. In order to commence the attack upon the problems it has been proposed

that a certain number of transmitting stations should execute at suitable hours some particular emissions of which the wavelength (or frequency) and the intensity of the current in the antenna should be accurately measured. A certain number of observers, distributed in the receiving stations of different countries, should establish the intensity of these signals or better that of the corresponding electromagnetic field and possibly also the direction of propagation.

The U.R.S.I. signals should last three full minutes; the first minute will serve for the regulation of the receiving apparatus and will be occupied with the repeated emission of a signal composed in the following way :—

"URSI—of (name of the station)—(wavelength in metres of the emission made the day before)—(intensity of current in amperes during that same emission)" as, for example, "URSI of XY—18,500—230." The succeeding two minutes should be occupied in the emission of a long dash. There should then be sent to the general secretariat (at Brussels) the schedules of each transmitting station, containing the largest possible number of technical data upon the emissions carried out, on the antenna, on the apparatus, on the meteorological conditions, etc. Analogous data should be despatched also by the stations that send out signals at regular times because they also are able to serve for measurements of intensity of reception. All these data should be rapidly co-ordinated by the general secretariat and should be printed and distributed widely to those interested. In the same way by each receiving station there should be registered and transmitted the data relative it may be to the intensity of the electromagnetic field on arrival produced by the emission considered, it may be (possibly) to the direction of propagation, together with all the suitable accessory indications—technical, meteorological, etc.

The study of *atmospheric disturbances* * represents perhaps to-day the most important problem of radiotelegraphy and extends from inquiries into their origin and into their nature, to the determination of the fundamental principles on which to base the methods of eliminating their injurious effects. This is a field of study in which only a vast organisation of experimental researches executed concordantly and simultaneously by a great number of observers is able to lead to conclusive results. The most important points for examination seem to be (1) the preponderant direction in which the atmospherics apparently arrive at each station, (2) the intensity of the atmospherics, (3) the simultaneity and the differences of intensity of the same atmospherics appearing at different stations, (4) the classification of the atmospherics on the basis of the preceding elements and of all the other characteristics that it shall be shown eventually opportune to define. To these researches could be dedicated the same receiving stations organised for the measurements on the law of propagation, and as reference with respect to the time and for observations of intensity, the URSI signals and the time signals could serve. In particular it is easy to see how useful might turn

* *L'Elettrotecnica*, 5, No. 10, p. 140, April 5th, 1918; 7, No. 1, p. 19, January 5th, 1920; and *Bollettino Radiotelegrafico*, 1, No. 1, p. 4; No. 8, p. 198.

out to be comparisons made between the curves of graphical registration obtained simultaneously in different stations and reproducing the same signals together with the atmospherics that accompany them. The results of the experiments collected in the first period of functioning of the projected organisation could serve to make more precise and uniform the collection of the data in the succeeding periods.

The directorate of the R.T. services of the Italian navy has already declared itself prepared to participate from the beginning in the experiments of scientific radiotelegraphy, proposing that our largest station actually in service, namely, the Rome Radio (San Paolo), should participate in the emission of the URSI signals.

The Amplification of Weak Alternating Currents.

II.—THE GRID CIRCUIT AND INPUT TRANSFORMER.

By H. BARKHAUSEN.

3. The Power supplied to the Grid Circuit.

(a) Very great Impedance $\boldsymbol{Z_u}$ of the External E.M.F.

The unamplified power P_u can also be thought of as supplied from a source with an E.M.F. $\boldsymbol{E_u}$ and an internal impedance which, for the present, can be denoted by $\boldsymbol{Z_u}$. The object of the connections is to maintain as high as possible the alternating pressure V_g on the grid in order that the strongest possible alternating current will be produced on the anode side. Now it is known that the grid, with a sufficiently high negative potential (about — 1 volt) takes no current and also consumes no power, thus representing in some respects an infinitely great resistance. A closer consideration shows, however, that a finite impedance must still be assumed. One sees this best by considering the case in which the internal impedance $\boldsymbol{Z_u}$ of the external E.M.F. $\boldsymbol{E_u}$ is very great. This occurs in fact in the discharge through a gas as, *e.g.*, with the amplification of the currents in photo-electric cells and also in other cases.* On account of its disturbing effect a case of practical importance is that of a quite small antenna (A, Fig. 9), a short wire connected to the otherwise insulated grid G. The E.M.F. $\boldsymbol{E_u}$ can arise in this case from the electric field of some alternating electric charge $\boldsymbol{Q}$ for example on a neighbouring lighting main. Its internal impedance $\boldsymbol{Z_u}$ is then equal to $1/\omega C_u$ if C_u is the partial capacity of A with respect to Q. The completely insulated grid then receives some alternating potential depending on the capacity C_g to earth (*i.e.*, to the earthed filament), of the grid together with the antenna and the connecting leads. The pressure $\boldsymbol{E_u}$ is divided in the

* The multiple amplifier, mentioned later, forms an important application. See Fig. 16.

ratio of $\boldsymbol{Z}_u = 1/\omega C_u$ and $\boldsymbol{Z}_g = 1/\omega C_g$ so that the pressure on the grid will be

$$V_g = \boldsymbol{E}_u \frac{\boldsymbol{Z}_g}{\boldsymbol{Z}_g + \boldsymbol{Z}_u}.$$

If the negative potential of the grid is insufficient or the insulation imperfect a suitably large resistance must be imagined connected in parallel with C_g; both are then included in the effective impedance $\boldsymbol{Z}_g$. In this last case it will be seen that in calculations the grid must be regarded as a resistance on which the E.M.F. acts, as mentioned previously. The novelty here is that this resistance is extraordinarily great and not well defined.

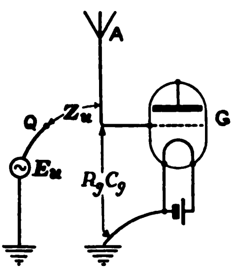

FIG. 9.

It is, besides, clear that a high potential can be the more easily maintained on the grid the greater the effective grid impedance $\boldsymbol{Z}_g$. On the other hand, as the above-mentioned example shows, all external disturbances, due to capacity or insulation, act more strongly when $\boldsymbol{Z}_g$ is at the same time greater. It is astonishing how with great amplifications and very large values of $\boldsymbol{Z}_g$ commutator noises and the like are often heard from lighting circuits which pass at a great distance. No particular antenna is required for this, the capacity of the grid and the terminals of the tube itself associated therewith being quite sufficient. Besides these disturbances due to stray fields the reaction from the anode circuit can never be neglected with large values of $\boldsymbol{Z}_g$. The anode itself has a capacity to the grid which is not negligible. More will be said later on this subject. With such back-coupling self-excitation occurs with extraordinary ease when $\boldsymbol{Z}_g$ is large; the tube then, in general, no longer works as an amplifier but as a generator (sender), which produces a particular alternating current entirely independent of external E.M.F. For these reasons large values of the impedance $\boldsymbol{Z}_g$ are dangerous, if not impossible.*

Besides the alternating current the direct current relations must be considered. A completely isolated grid is charged by the electrons thrown off from the filament to a potential of -1 or -2 volts according to the insulation, the anode pressure, and the tube construction. This is only the case with a very high vacuum in the tube and with very good insulation. There is also the danger of surface leakage currents from the high positive anode potential, the leads for which lie close to those of the grid. Finally as is frequent, *e.g.*, with photo-electric cells, besides the alternating pressure $\boldsymbol{E}_u$ (Fig. 9) a direct pressure is active, supplying a direct current to the grid. Then a high ohmic resistance or a choking coil must be provided as a leak to the grid. The effective impedance $\boldsymbol{Z}_g$ will be reduced thereby. For higher frequencies particularly, a choking coil cannot be made of high impedance, since with a large number of turns the unavoidable coil capacity

* With many amplifiers $\boldsymbol{Z}_g$ is intentionally diminished by use of an insufficient negative pressure on the grid ($-0\cdot5$ volt). Increasing the latter sets up self-excitation directly. See also Section 5 (*c*).

forms a shunt through which the alternating current passes. It is best to work with resonance. Details are discussed with the input transformer (see below) in which these relations are just as important.*

(*b*) *Input Transformer.*

Generally the internal impedance $\boldsymbol{Z}_u$ of the source of current to be amplified is not so extraordinarily great that the pressure cannot be increased by means of a step-up transformer. This amounts to an adaptation of $\boldsymbol{Z}_u$ to the nearly infinitely great grid impedance $\boldsymbol{Z}_g$ (Fig. 10). One might imagine that with the transformer it is only necessary to have the highest possible number of secondary turns. A limit is soon reached in practice, beyond which not an increase but a reduction of pressure occurs. The reason for this is the capacity of the winding. The transformer must not only charge the grid but also a part of its own secondary winding. This acts as if a capacity C—shown dotted in Fig. 10—were connected across its secondary

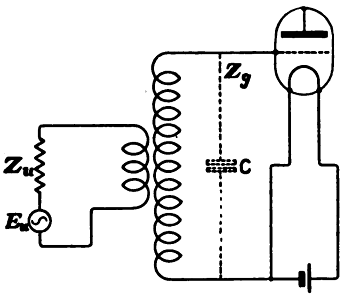

FIG. 10.

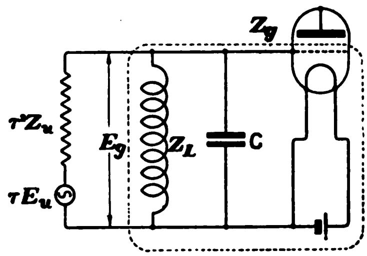

FIG. 11.

terminals. For a given number of turns this comes into resonance with the inductance of the winding and thus produces a pressure increase. With still more turns, however, resonance is exceeded and the pressure falls more and more. These natural oscillations of coils are quite well known in high frequency technology.

The phenomena occurring here can best be explained by the use of an equivalent circuit in which the magnitudes of the primary circuit are reduced to the secondary circuit. For this the E.M.F. $\boldsymbol{E}_u$ is multiplied by the transformation ratio τ and its internal impedance $\boldsymbol{Z}_u$ by τ^2. The external impedance $\boldsymbol{Z}_g$ upon which the E.M.F. acts consists then of the unloaded secondary winding, which must be thought of as a choking coil $\boldsymbol{Z}_L$ having the coil capacity C in parallel with it and parallel thereto the grid of the tube. (See Fig. 11.) The grid potential V_g, *i.e.*, the pressure across $\boldsymbol{Z}_g$ is then

$$V_g = \tau \boldsymbol{E}_u \frac{\boldsymbol{Z}_g}{\tau^2 \boldsymbol{Z}_u + \boldsymbol{Z}_g}.$$

This will be a maximum, equal to $\tau \boldsymbol{E}_u/2$, for a value of the transformation

* See also the section "Multiple amplifiers" (*in next issue*).

ratio such that $\tau^2 Z_u = Z_g$; thus, as would be expected, with equality of the internal and external impedances, Z_g depends upon the frequency and will be a maximum at resonance of the winding together with the tube. These are the same phenomena which were fully discussed in connection with Figs. 4 and 5 for the anode circuit. Here, therefore, only the experimental confirmation of this theory will be mentioned.

That exactly the same phenomena occur with input transformers at audible frequencies has been proved, particularly by the comprehensive measurements made by K. Mühlbrett.* The impedance of the open-circuited, unloaded input transformer was measured on the primary side by various methods and shows a dependence on frequency exactly like the normal resonance curves drawn in Figs. 5 and 12. The logarithmic decrement d for audible frequencies was in the neighbourhood of 0·6, the resonance frequency being usually over 1,000. The connection of a known capacity on the secondary side caused a displacement of the curve towards lower frequencies in accordance with the Thomson formula. Thence it was calculated that without the additional condenser, the effective coil capacity alone was about 80 cm on the average, but by varying the polarity of the winding a difference of 40 per cent. in the resonance frequency could be observed, indicating a change of 100 per cent. in the effective capacity, *i.e.*, from 1 to 2. This is due to the end capacity which here comes into play. A condenser connected to the primary acts moreover as if connected on the secondary, only reduced by the square of the transformation ratio. With very small values of Z_u the secondary voltage V_g on which the amplification depends was always equal to τE_u. Only with heavier loads one obtained a small pressure drop depending on the ohmic resistance. Under these conditions resonance phenomena did not occur. The greater Z_u is made the more pronounced are the resonance phenomena, and so soon as $\tau^2 Z_u$ becomes large compared with Z_g, the secondary pressure varies with frequency directly as the impedance Z_g, when the frequency is altered at constant E.M.F. These are exactly the phenomena described in connection with Fig. 4 with respect to the relation between Z_t and Z_u.

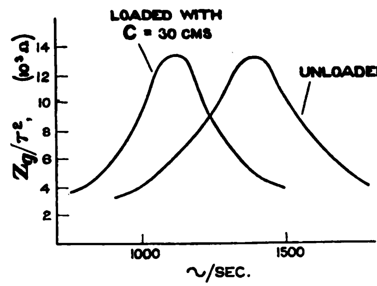

FIG. 12.

The value of $1/\omega C$ for a frequency of 1,000 with $C = 80$ cm is equal to 2×10^6 ohms; the resonance impedance, π/d times as great, is with $d = 0{\cdot}6$ about 10 megohms. A shunt by means of an ohmic resistance of equal

* Following my first experiments on input transformers for audible frequencies (February, 1917) which gave the resonance effect and the magnitude of the coil capacity, **Mühlbrett** has later—on my suggestion—extended these measurements. The results were reported in the *Archiv. für Elektrotechnik* (9, pp. 365—390, December 8th, 1920).

† Similarly, very exact experiments on a measuring transformer for use with an electrometer at a frequency of 50 are described by **Gewecke** (*Archiv. für Elektrotechnik*, 8, p. 203, 1919). The theoretical hypotheses are more nearly fulfilled in this case.

magnitude must thus reduce the effective resistance R_g to one half. This is also confirmed by the measurements (Fig. 13). A load of 1 megohm destroys the resonance effect almost completely. Thus if it is desired to utilise the entire pressure increase due to resonance the insulation must be very good, *i.e.*, great compared with 10 megohms.

The supply of energy due to back coupling can be treated in calculation as a load with negative resistance. This diminishes the normal positive resistance, thus increasing the resonance peak; experiment has also confirmed this (Fig. 14). If the negative resistance is as great as the positive, the resonance impedance becomes infinite, and with still greater * negative resistances self-excitation occurs. It is physically clearer if one considers the strength of the current which must be supplied to the transformer primary in order to produce a definite pressure, *e.g.*, 1 volt on the secondary.

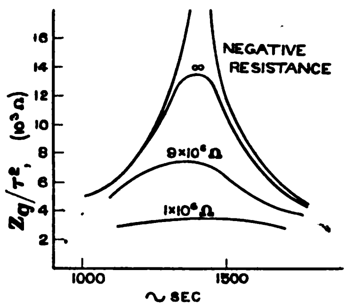

FIG. 13.

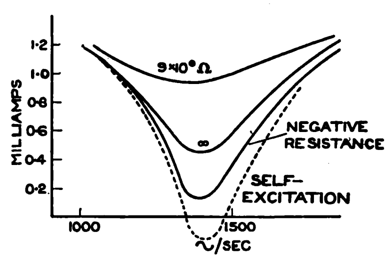

FIG. 14.

As Fig. 14 shows this current will be a minimum at resonance; these curves are simply the reciprocals of the impedance curves of Fig. 13.† By loading with a positive resistance the minimum does not fall so low since the load current is added. On the other hand, by loading with a negative resistance the curve approaches the zero line more or less, according to its magnitude. If this be reached no further supply of current is necessary; a resonant oscillation once excited maintains itself, dying out infinitely slowly. Then a continued echo is heard in the amplifier with each impulse. If the zero line be crossed over with stronger back coupling the resonance oscillation maintains itself even without external impulses. This also was confirmed experimentally.

(c) *Influence of the Capacity between the Grid and the Anode.*

With great values of Z_g the capacity C_{ga} between the grid and anode is also to be considered. It forms a "back coupling," a retro-active effect of

* *Translator's Note.*—The author says, "bei noch kleinerem negativen Widerstand," but the context clearly shows that greater and *not* less resistance is meant.

† Most of the current curves of Fig. 14 were experimentally found by **Mühlbrett** (*l. c.*) and therefrom the resistance curves of Fig. 13 were calculated.

the amplified currents in the anode circuit upon the unamplified currents in the grid circuit. The general theory of this back coupling will be treated later; the effect of the capacity C_{ga}—which in the following is simply denoted by C—is here only briefly discussed. It causes a charging current which, according to the laws of alternating currents, is calculated from the equation

$$\frac{I_c}{j\omega C} = V_g - V_a = V_g\left[1 + \frac{\mu}{(1 + R_i/\boldsymbol{Z_a})}\right]$$

because the charging current is dependent on the pressure across the terminals of the capacity, *i.e.*, on the difference between the grid and the anode potentials, and the alternating pressure on the anode depends on the grid potential and the impedance $\boldsymbol{Z_a}$ in the anode circuit according to the equation,

$$V_a = V_g \frac{\mu}{(1 + R_i/\boldsymbol{Z_a})}.$$

Thus the charging current is calculated from the grid potential only and the ratio of both

$$\frac{V_g}{I_c} = \boldsymbol{Z_c} = \frac{1}{j\omega C} \frac{1}{1 + \dfrac{\mu}{(1 + R_i/\boldsymbol{Z_a})}} = \frac{1}{j\omega C} \frac{(1 + R_i/\boldsymbol{Z_a})}{(1 + R_i/\boldsymbol{Z_a}) + \mu}$$

is the equivalent impedance which, connected between the grid and the filament, will give the same charging current.

If $\boldsymbol{Z_a}$ is small compared with R_i, *i.e.*, if the anode is connected with the filament through a negligible resistance, $\boldsymbol{Z_c} = 1/j\omega C$ simply. This is obvious since the capacity C is then practically connected between the grid and the heater.

If, on the other hand, $\boldsymbol{Z_a}$ is great compared to R_i,

$$\boldsymbol{Z_c} = \frac{1}{1 + \mu} \cdot \frac{1}{j\omega C},$$

so that the effective capacity will be $1 + \mu$ times as great; for example, when $\mu = 20$ being increased 21 times. This is because the anode potential is μ times as great as the grid potential and induces correspondingly stronger charges on the grid. If $\boldsymbol{Z_a} = R_i$ the effective capacity is only about half as great, *i.e.*, increased $\mu/2$ times.

A pure capacity effect only happens when $\boldsymbol{Z_a}$ is entirely real. In other cases the anode pressure is no longer in phase with the grid pressure, and therefore the charging current is not displaced 90° from it. For the equivalent impedance a capacity with an appreciable leak, *i.e.*, one with an ohmic resistance connected in parallel with it, can be used in the calculations. For the sake of simplicity we shall only consider the cases in which the anode impedance is either entirely inductive ($\boldsymbol{Z_a} = j\omega L$), or entirely capacitive ($\boldsymbol{Z_a} = 1/j\omega C$). Let its absolute value be $1/n$ times as great as R_i, so that the ratio $R_i/\boldsymbol{Z_a}$ will be $n/j = -jn$ in the case of the inductance and $+jn$ in the capacitive case. If it be desired to analyse the expression into real and imaginary parts for a capacity having a resistance in parallel with it

the value, G_c, of the admittance must be calculated.* Thus, in the inductive case,†

$$\frac{1}{Z_c} = G_c = j\omega C\left[1 + \frac{\mu}{1 - jn}\right] = j\omega C$$
$$\frac{(1 - jn + \mu)}{(1 - jn)} = j\omega C\frac{(1 + n^2) + \mu}{(1 + n^2)} - \omega C\frac{n\mu}{(1 + n^2)}.$$

For $n = 1$, *i.e.*, $Z_a = jR_i$ this gives

$$\frac{1}{Z_c} = G_c = j\omega C\frac{2 + \mu}{2} - \frac{\omega C\mu}{2}.$$

The first, imaginary term represents the effective capacity; the second, real term the leak. With a large μ the second term is as great as the first; the leak then lets through as much current as the capacity itself. The equivalent impedance Z_c possesses a phase displacement of 45°, as was to be expected, since with $Z_a = jR_i$ the anode pressure V_a is displaced from V_g by about 45°. In the capacitive case, n is only substituted for $-n$ throughout; thereby merely altering the sign of the second term.

With a capacitive Z_a a positive leak is obtained which consumes energy and has a damping action; with an inductive Z_a, on the other hand, the anode capacity C_{ga} acts as a capacity with a negative leak, which diminishes the damping and annuls the effect of an equally great positive leak. If the negative leak be greater than the entire positive leak self-excitation occurs, resulting entirely without external causes from its own alternating currents; the amplifier "whistles" and cannot be used.‡

The phenomena actually occurring become thereby rather indefinite, since all impedances depend in amplitude and phase on the frequency. For example, if Z_a is a coil with a capacity connected in parallel with it, or even with its own winding capacity, Z_a is inductive for frequencies lower than the resonance frequency, but capacitive for higher frequencies. Lower frequencies are therefore amplified, whilst higher frequencies are damped. If self-excitation is to be safely avoided, the conditions of resonance of Z_a must be chosen so low that the oscillations which can arise, and whose frequency will be essentially determined by the resonance conditions of Z_g, possess a higher frequency than Z_a.§ All this was also confirmed experimentally as will be described in a later work.

It should be noticed that the capacity C_{ga} is formed not only by the electrodes which are in the tube, but also by their associated conductors—so far as they carry potentials themselves—thus also by means of the terminals

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* I have carried out the calculation for this case. An equivalent capacity with a series resistance is then obtained.

† *Translator's Note.*—There is an error in the real term as given by the author. The factor $(1 + n)$ in the denominator should be $(1 + n^2)$.

‡ Certain transmitting valve circuits are based upon such self-excitation due to the capacity C_{ga}.

§ Without knowledge of this theory condensers for removing disturbances have occasionally been connected in parallel with the output transformer Z_a to suppress the self-excitation.

and connecting leads outside the tube.* Lengthy neighbouring connecting leads quite substantially increase the otherwise very small capacity. It is often observed that self-excitation may be started or stopped by quite a small to and fro movement of these connecting leads. This can even be effected by bringing the hand closer or further away, since by the closeness of stray conductors the partial capacity between two leads will be altered.

In normal cases $\boldsymbol{Z_a}$ is of the same size as R_i. Then the effective capacity which diminishes R_g, is about $\mu/2$ times as great as C_{ga}, *e.g.*, when $\mu = 100/7$ and $C_{ga} = 10$ cm about 70 cm. A capacity of this size must thus be imagined connected between the grid and the filament. The natural frequency of the input transformer will be considerably reduced thereby, and this explains the experimentally observed fact — mentioned above — that the open-circuited transformer not connected to the grid should be tuned to a higher frequency than that to be amplified. This particular effect of C_{ga} can also be easily demonstrated experimentally. If a transformer be loaded with a tube, the anode of which is directly connected to the battery, its condition compared with open-circuit is not at all altered, assuming the grid current of the tube to be zero. But as soon as a very high resistance $\boldsymbol{Z_a}$ is connected in the anode side, the tube acts as if the transformer were loaded with a large capacity.†

High-speed Wireless Telegraphy.

At a meeting of the Wireless Section of the Institution of Electrical Engineers on January 4th, a paper on this subject was read by Lieut.-Colonel A. G. T. Cusins, Royal Corps of Signals, the officer in charge of the Signals Experimental Establishment at Woolwich. The paper consisted in the main of a record of the development of high-speed telegraphy carried out at Woolwich and applied in the communication between Aldershot and Cologne and other military centres. Every effort had been made towards the mechanicalisation of wireless telegraphy in as simple and portable a form as possible. The apparatus can be operated up to the maximum speed of the Wheatstone apparatus. In practice the message is recorded on a Wheatstone receiver, but at the meeting at the Institution a very successful demonstration was given of reception from Woolwich, in which the message was printed by means of a Creed perforator and printed at a speed of about 100 words per minute. The transmitter operates by cutting out a battery which normally maintains a high negative potential on the grid of a valve which is inserted as a leak in the grid current of the main transmitting valve.

The receiver consists of a Turner valve relay, coupled to the aerial through a three-valve H.F. amplifier. The quenching of the valve relay is done electrically by inserting a control valve in its anode circuit, the grid of this control valve being modulated by an oscillating valve of audible frequency (1,000 to 3,000). The P.D. across a resistance in the anode circuit of the valve relay acts on the grid of another valve which acts as a rectifier and which operates a Post Office relay through a double-current valve relay. The Post Office relay operates a Wheatstone receiver.

Towards the end of the paper, however, the author mentioned that the Turner valve relay had now been superseded by another device called the "Autokym" but of which the details were not disclosed. The author mentioned that experiments had been made with a chemical

* A double-grid tube with a protective grid between the control grid and the anode considerably reduces the capacity of the tube itself, but not that of the leads. Since the voltage ratio μ is large these tubes give particularly strong back coupling with large values of $\boldsymbol{Z_a}$.

† See **K. Mühlbrett** (*l. c.*).

inker giving perfect signals at 3,000 words per minute, but that the method needs further development.

The reading of the paper was followed by a lengthy discussion. Mr. Carpenter gave some particulars of the advantages of the Creed apparatus which employs the ordinary Morse signals as compared with other printing systems employing the five-unit system. Mr. Creed himself spoke of the vista opened up by the enormous strides being made in the development of radio telegraphy. Captain Turner drew attention to the limitations of high-speed signalling at very long wavelengths on account of the time taken to build up an oscillation in a circuit in which the damping had been reduced in order to increase the selectivity and freedom from atmospheric disturbances. Mr. Shaughnessy referred to successful experiments in high-speed wireless carried out by the Post Office some years ago. He considered that the author had been unduly optimistic in his visions of the future developments of the high-speed broadcasting of news from a national press centre. Captain Round drew attention to what was perhaps one of the outstanding features of the system described and that was the variety of applications and possibilities of the three-electrode valve. Mr. Scott-Taggart described two methods of using three-electrode valves which he had devised, which could be employed in high-speed reception.

The Physical Society of London and the Optical Society.

The Twelfth Annual Exhibition of Electrical, Optical, and other Physical Apparatus.

This annual exhibition was held at the Imperial College of Science, South Kensington, on the afternoons and evenings of January 4th and 5th. The number and interest of the exhibits was quite up to the usual standard. On each day Mr. Campbell Swinton gave an experimental lecture on "The Johnsen-Rahbek Electrostatic Telephone and its Predecessors."

Of special interest in the wireless section was the exhibit of Messrs. Creed & Co., consisting of a complete high-speed automatic printing telegraph, the receiver being operated from a temporary aerial and printing high-speed messages transmitted automatically from a distant station.

H. Tinsley & Co. were showing two new types of variable inductometers; there is an increasing tendency to use bridge methods involving variable inductometers in accurate alternating measurements and improvements in the design are to be welcomed if they will enable them to be used at higher frequencies. The same firm also exhibited compact bridges for measuring inductance and capacity of the type designed by Mr. L. B. Turner.

Of interest to those using portable ammeters and voltmeters were the so-called Resilia instruments shown by the Foster Instrument Co., of Letchworth. In these the moving coil is pivoted internally on a support which is not fixed rigidly to the iron core but carried on a spring, thus relieving the pivots of all shock.

The Weston Electrical Instrument Co., Ltd., were showing their well-known thermo-ammeters and galvanometers for radio frequencies.

Mr. H. W. Sullivan exhibited a great number of instruments of interest to the radio engineer, including valve oscillators of both radio and audio frequencies, variable and fixed condensers, both of ordinary and of special quality, wavemeters and variometers. He also showed a Wheatstone bridge for radio frequencies, with a vacuum thermo-galvanometer as an indicator; the resistance arms are carefully constructed to be non-reactive and all parts of the bridge are carefully screened (see page 79 for fuller description).

The Igranic Electric Company showed a selection of machine-wound duolateral coils, so dear to the heart of the wireless amateur.

The Dubilier Condenser Company showed a number of their well-known mica condensers of various types and also the Dubilier insulator which has been specially designed to stand up against C.W. working.

A selection of wireless apparatus, condensers, amplifiers, etc., was shown by Gambrell Bros.

Professor Taylor Jones exhibited a new electrostatic oscillograph for use with potentials from 5,000 to 250,000 volts. This consists of a metal strip of adjustable tension supported

between ebonite jaws; the centre of the strip rocks a mirror pivoted about a fixed fulcrum. In front of the strip is a metal plate connected electrically with it whilst the other terminal is connected to an electrode behind the strip but embedded in ebonite. The strip is thus attracted to this electrode with a force proportional to the square of the voltage, and—a point not mentioned in the printed description—the movement is independent of the reversal of the applied P.D. This latter is certainly an unusual feature in oscillographs.

Marconi's Wireless Telegraph Company exhibited their emergency "4-Second Alarm" device, which enables a ship in distress to call up another in the event of the receiver on the latter being temporarily unattended.

Notes.

Commercial and General.

Government Control of Wireless in California.—The Minister of Communications for Mexico has issued orders placing the wireless stations in the northern part of Lower California under the jurisdiction of the Telegraph Department with the object of placing the majority of the scattered wireless telegraph stations under the control of the Federal Government. **[4069]**

Wireless Telephony in Sweden.—The Telegraph Authorities are now conducting experiments for linking up the ordinary telephone with the wireless telephone so as to enable through calls to be effected. **[4065]**

Wireless Telephony on Railways.—According to *Telegraph and Telephone Age* wireless telephones are to be installed on a number of German express trains to provide communication between the passengers and hotels, etc. **[4074]**

Wireless Telephony.—According to the *Deutsche Allgemeine Zeitung*, highly successful experiments in wireless telephony have recently been carried out between Berlin and Copenhagen. **[4146]**

According to the *Electrician* encouraging experiments in wireless telephony have been carried out by the Indian Posts and Telegraphs Department between Bombay and Poona. **[4156]**

New Wireless Station in North Africa.—The building of the wireless station at Ain-el-Hadjar, near Saida, on the railway line from Perregaux to Colomb-Bechar, has just been started by a detachment of military engineers. The station, which will be the most important in North Africa, is intended to form the wireless link between France and her African colonies, and in case of a breakage of the undersea cables to undertake the forwarding of telephone messages between France and Algeria. **[4238]**

Wireless telegrams can now be sent between Bordeaux and Madagascar. The rate is 2.25 fr. per word. **[4421]**

Increase in Ship Station Rate for United States Shipping Board Vessels.—Effective January 1st, 1922, the ship tax of all Shipping Board vessels will be advanced from 4 cents per word to 8 cents per word. **[4488]**

The Thermionic Valve and Arc as Generators for Radiotelegraphy.—A course of eight lectures on the above subjects has been arranged at East London College (Mile End Road, E. 1), commencing on February 7th, and continuing on the seven following Tuesdays. The first five lectures will be given by Professor W. H. Eccles, D.Sc., and the remaining three by Mr. C. F. Elwell, M.I.E.E. Syllabus and full particulars may be obtained from the Registrar of the College.

Review of Radio Literature.

1. Abstracts of Articles and Patents.

(F.) Thermionic Valves, and Valve Apparatus.

2943. **H. St. J. de A. Donisthorpe.** Thermionic Valve for use in Wireless Telegraphy and Telephony. (*U.S. Patent* 1391671, March 23rd, 1921. Patent granted September 27th, 1921.)

See RADIO REVIEW Abstract No. 2582, November, 1921, for corresponding British Patent.

2944. **C. E. Hiatt** and **W. J. Davis.** Valve of Wireless Transmission Systems. (*U.S. Patent* 1394090, May 19th, 1919. Patent granted October 18th, 1921.)

A tube having a construction of plate which provides a high thermal conductivity between the plate and its support and which at the same time is of inexpensive manufacture.

2945. **W. C. White** [General Electric Company]. Means for Producing High-frequency Oscillations. (*U.S. Patent* 1393594, June 3rd, 1918. Patent granted October 11th, 1921.)

A means for producing high-frequency oscillations independently of any coupling between the grid and plate circuits of the vacuum tube oscillator. Under certain conditions in vacuum tube oscillator circuits, the current in the grid circuit may have a falling characteristic, that is, as the voltage impressed upon the grid increases, the current in the grid circuit will decrease. With the proper conditions for operation, a circuit having current characteristics of the type described, may be so organised that oscillations will be produced therein, the essential condition for the production of oscillations being that the circuit shall contain capacity and inductance and that the resistance of the circuit shall be less than :

$$2\sqrt{L/C}$$

where L represents the inductance and C the capacity of the circuit. A resonant grid circuit is provided including a source of potential and adjusted so that the current in the grid circuit will vary inversely as the applied potential over a given operating range of negative potential, the source of potential connected to the grid circuit being of such value that the normal potential of the grid is within the operating range, whereby oscillations will be produced in the grid circuit independently of any coupling between the grid and plate circuits. (See also Abstract No. 2613, November, 1921, for corresponding British Patent.)

2946. **W. C. White** [General Electric Company]. Signalling System. (*U.S. Patent* 1394056, July 3rd, 1920. Patent granted October 18th, 1921.)

A transmitter employing vacuum tube oscillators and modulators. A source of alternating current of low frequency is provided for supplying energy for the operation of the electron discharge oscillators and the modulators. Current for heating the filaments of the oscillators and modulators is also deriv.d from the same source. Current for the operation of the oscillators and modulators is supplied to the plate circuits by means of a transformer, the secondary of this transformer being oppositely connected to the plate circuits of the oscillators as well as to the plate circuit of the modulators.

2947. **P. C. Hewitt.** Relay. (*U.S. Patent* 1393018, March 9th, 1916. Patent granted October 11th, 1921.)

A tube comprising an evacuated vessel having an anode and a cathode therein, a battery connection for heating the cathode, a conducting member acting as a screen enclosed within the container and adjacent to the anode and means for heating the conducting member to a temperature having any desired relation to the temperature of the heated cathode. The tube is intended for amplifying electrical currents or translating variations and when used in such connection either the cathode or the screen may serve as the grid and the temperature of each may be controlled in such manner as to pass the desired amount of current in either direction.

(G.) Transmitter Control or Modulation.

2948. **C. V. Logwood.** Signalling System. (*U.S. Patent* 1397432, June 16th, 1917. Patent granted November 15th, 1921.)

This patent relates to a radio transmitting and receiving vacuum tube apparatus with means for automatically switching from transmitting to receiving.

2949. **E. O. Scriven** [Western Electric Co., Inc.]. System for Transmission of Intelligence. (*U.S. Patent* 1396786, November 6th, 1916. Patent granted November 15th, 1921.)

This invention relates to a radio telephone system wherein signals are transmitted or received by means of a high-frequency carrier wave modulated in accordance with the signals. The circuit embodies the combination of two vacuum oscillators which serve as a source of high-frequency carrier wave oscillations, the impedance of which combination is varied according to the low-frequency signals to be transmitted. By suitable adjustments the radiation of the unmodulated carrier wave can be prevented.

At the receiver a vacuum tube containing two grids, two plates, with common filament is employed. The circuit may be arranged for either high-frequency carrier wave reception or modulated high-frequency wave reception, in which latter case the tube serves as a homodyne generator, that is, it should produce oscillations of the same frequency as the incoming high-frequency oscillations. If the incoming waves are not modulated the vacuum tube generator should be a heterodyne generator, that is, it should generate oscillations of a frequency different from that of the incoming carrier waves to produce a frequency within the limits of audition.

2950. **A. L. Fitch** [Western Electric Co., Inc.]. Transmission System. (*U.S. Patent* 1397862, November 26th, 1917. Patent granted November 22nd, 1921.)

This invention relates to a radio telephone modulating circuit employing a condenser transmitter connected to a vacuum tube amplifier and using a single battery both in the output circuit of the amplifier and as a means for polarising the transmitter. In the usual operation of a vacuum tube amplifier circuit with condenser telephone employing a single battery as described, the filament is usually grounded and accidental grounding of the condenser transmitter case causes either the battery or the condenser transmitter to be short-circuited and thus interferes with the operation. The present invention remedies this defect by connecting the battery to perform both the functions of charging the condenser transmitter and furnishing current to the output circuit in the amplifier circuit such that one electrode of the condenser transmitter is always grounded and the other electrode is arranged to make grounding substantially impossible. The source of electromotive force is common to both the circuits through the condenser transmitter and the output circuit of the vacuum tube amplifier.

2951. **L. Espenschied** [American Telephone & Telegraph Company]. Radio Repeating System. (*U.S. Patent* 1397093, September 27th, 1919. Patent granted November 15th, 1921.)

This invention relates to radio repeating stations and apparatus for amplifying at intermediate points the signals transmitted between two terminal stations.

2952. **E. W. B. Gill** [Radio Corporation of America]. Wireless Telegraph Receiver. (*U.S. Patent* 1371757, October 7th, 1920. Patent granted March 15th, 1921.)

See corresponding *British Patent* 155642, RADIO REVIEW Abstract No. 2933, January, 1922.

2953. **E. F. W. Alexanderson** [General Electric Company]. Radio Receiving System. (*U.S. Patent* 1373931, June 5th, 1919. Patent granted April 5th, 1921.)

See RADIO REVIEW Abstract No. 2967 in this issue.

(H.) Radio Receiving Apparatus.

(3) ELECTRON TUBE DETECTORS AND RECEIVERS.

2954. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Systems. (*British Patent* 160140, March 11th, 1921. Convention date March 13th, 1920. Patent not yet accepted.)

An arrangement of valves to separate the functions of high and low-frequency amplification and to minimise the effects of atmospherics (Fig. 1). Modifications on similar lines can also be arranged, by replacing the resistances R_1 R_2 by inductances.

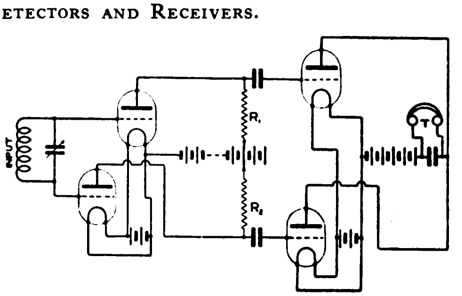

FIG. 1.

2955. **Gesellschaft für drahtlose Telegraphie.** Oscillation Generators. (*British Patent* 147435, July 7th, 1920. Convention date December 6th, 1917. Patent not yet accepted.)

In a thermionic oscillation generator tuned circuits are inserted as impedances in the plate circuit for the purpose of minimising heat losses, particularly in the electrodes of the valve. The choking circuits for harmonics may be connected in series or parallel as shown in Figs. 2 and 3. The antenna may be coupled or directly connected to the circuit of fundamental frequency.

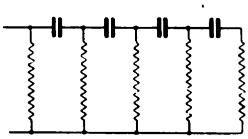

FIG. 2.

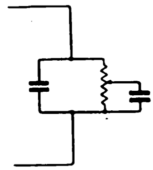

FIG. 3.

2956. **E. Hoghton** [Portholme Aircraft Company]. Wireless Receiving Apparatus. (*British Patent* 162097, January 28th, 1920. Patent accepted April 28th, 1921.)

Valve-receiving apparatus using retroaction between the anode and grid circuits, the grid winding being joined between the tuned receiving circuit and the grid of the valve instead of in series with the tuned circuit.

2957. **J. Scott-Taggart.** Thermionic Valve Circuits. (*British Patent* 152693, July 25th, 1919. Patent accepted December 25th, 1920.)

Relates to the use of two valves having the anode of the first connected to the grid of the second, and the anode of the second connected to the grid of the first. The arrangements are applicable to receivers, amplifiers, oscillation generators, etc.

2958. **E. H. Armstrong.** Wireless Receiving Apparatus. (*British Patent* 147042, July 6th, 1920. Convention date October 29th, 1913. Patent not yet accepted.)

Relates to the Armstrong "feedback" circuit, in which both grid and plate circuits are tuned to the signal frequency, and an inductance (such as the telephones) is included in the common portion of the two circuits so as to provide the retroaction.

2959. **J. Scott-Taggart.** Thermionic Detectors (*British Patent* 162710, December 3rd, 1919. Patent accepted May 3rd, 1921.)

Incoming energy is caused to vary the grid potential of a triode tube by altering the conductivity of a high-resistance body inserted in the grid circuit—such, *e.g.*, as glass maintained at a temperature just below that at which it becomes conducting.

2960. **R. A. Weagant** [Radio Corporation, U.S.A.]. Thermionic Valves. (*British Patent* 146534, July 5th, 1920. Convention date February 24th, 1915. Patent accepted October 5th, 1921.)

For the detection, amplification or generation of oscillations the tuned circuits are coupled together through a Fleming valve. The same connections may be used for both transmission and reception.

2961. **R. A. Weagant** [Radio Corporation, U.S.A.]. Thermionic Valves. (*British Patent* 146535, July 5th, 1920. Convention date April 25th, 1914. Patent accepted October 5th, 1921.)

Connections are given for a three-electrode thermionic valve for receiving spark or C.W. signals.

2962. **R. A. Weagant** [Radio Corporation, U.S.A.]. Thermionic Valves. (*British Patent* 146536, July 5th, 1920. Convention date February 1st, 1916. Patent not yet accepted.)

Relates to circuit connections for a two-electrode Fleming valve receiver.

2963. **Marconi's Wireless Telegraph Co., Ltd.** Thermionic Valves. (*British Patent* 157477, February 14th, 1919. Patent accepted January 27th, 1921.)

A thermionic valve having two control electrodes and two anodes so arranged that the electron stream is deflected to the anodes alternately.

2964. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Detectors. (*British Patent* 163487, February 20th, 1920. Patent accepted May 20th, 1921.)

The detector consists of a thermionic device possessing a substantially linear characteristic

(such as a tube containing two heated filaments as electrodes), and its resistance is periodically varied such as by a magnetic field excited by a local source of alternating current.

2965. **G. A. Mathieu.** Wireless Signalling. (*British Patent* 164900, April 1st, 1920. Patent accepted June 23rd, 1921.)

The filament of a valve amplifier is connected to a point in the inductance of a loop aerial or of an inductance in parallel with or coupled to the aerial. Alternative arrangements are shown in Figs. 4 and 5.

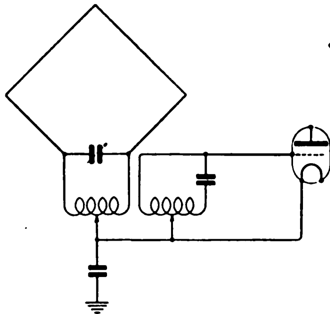

Fig. 4.

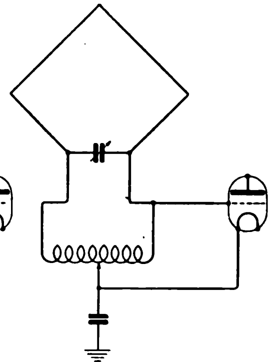

Fig. 5.

2966. **Gesellschaft für drahtlose Telegraphie m.b.H.** Relay. (*French Patent* 511244, April 1st, 1915. Published December 20th, 1920.)

The local circuit including the cathode and anode of a valve relay in the receiving system is supplied with an alternating current having a frequency near that of the incoming waves, thus producing beats of audible frequency. The cathode may be heated by an alternating current. (See also the corresponding *British Patents* Nos. 5342/1915 and 7358/1915.)

2967. **E. F. W. Alexanderson.** A Selective Receiver for C.W. Reception. (*Wireless Age*, 8, p. 24, July, 1921.)

Increased selectivity is obtained by arranging the receiving valve to be on the verge of self-oscillation so that the incoming signals when tuned to the same frequency cause local oscillations to be produced. These are arranged to upset the balance of the Wheatstone bridge having three-electrode valves in two of its arms and fed from an acoustic frequency alternating current. The incoming signals cause the bridge to be unbalanced so that the audio frequency current can pass through the telephone receivers connected to the bridge.

2968. **H. de A. Donisthorpe.** A Simple Valve Circuit and the Methods of Grid Potential Control. (*Model Engineer*, 45, pp. 266—267, September 29th, 1921.)

(4) Heterodynes and C.W. Receivers.

2969. **J. Scott-Taggart.** Continuous-wave Multi-stage Receiving Circuits. (*Electrician*, 85, pp. 441—442, October 15th, 1920. *Science Abstracts*, 23B, pp. 544—545, Abstract No. 1032, November 30th, 1920—Abstract. *Radioélectricité*, 1, pp. 79D—81D, January, 1921—Abstract. *Technical Review*, 8, p. 238, March 8th, 1921—Abstract.)

2970. **M. Latour.** The Heterodyne Method of Wireless Reception: Its Advantages and its Future. (*Radio Review*, 2, pp. 15—21, January, 1921.)

2971. **E. H. Armstrong.** A New Method for the Reception of Weak Signals at Short Wavelengths. (*Q.S.T.*, 3, pp. 5—9, February, 1920.)

See Radio Review Abstract No. 1668, April, 1921, for description of the same apparatus.

2972. **A. M. Goldsmith** [Marconi's Wireless Telegraph Co., Ltd.]. Wireless Receiving Apparatus. (*British Patents* 149282 and 149283, July 15th, 1920. Convention date July 28th, 1919. Patents not yet accepted.)

For the reception of C.W. signals it is proposed to modulate the received energy at an acoustic frequency by periodically varying the mutual inductance between the coupling coils of the receiver circuits. This may be effected by rotating between the coupling coils a disc provided with short circuited coils or other similar means of varying the mutual inductance.

2973. **R. A. Weagant** [Marconi's Wireless Telegraph Company]. Wireless Receiving Apparatus. (*British Patent* 161580, April 7th, 1921. Convention date April 14th, 1920. Patent not yet accepted.)

Refers to a heterodyne arrangement in which the frequency of the locally generated oscillations is widely different from that of the incoming signals. An intermediate circuit is tuned to the resulting beat frequency, and serves also to eliminate the frequency of the local oscillations. The beat frequency may be further modulated before reception in the telephones.

2974. A Buzzer Microtelephone for the Reception of Undamped Waves. (*L'Onde Hertzienne*, 1, pp. 71—72, October, 1920.)

In the arrangement described the reaction between the microphone and telephone produces a species of tikker which is used in conjunction with a resonance tube.

2975. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Receiving Heterodyne Arrangement. (*French Patent* 507197, December 9th, 1919. Published September 7th, 1920.) Also **I. Langmuir** [British Thomson-Houston Company]. (*British Patent* 147823, July 9th, 1920. Convention date December 29th, 1913. Patent not yet accepted.)

The received oscillations are conveyed to the grid while oscillations of a slightly different frequency are conveyed to the plate of a three-electrode valve. The beats between the two sets of oscillations are detected by a telephone.

2976. **H. G. Möller.** The Reception of C.W. as a Continuous Current by Means of the Autoheterodyne. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 256—287, April, 1921. *Telegraphen- und Fernsprech-Technik*, 10, p. 95, July, 1921. *Science Abstracts*, 24B, pp. 367—368, Abstract No. 761, July 30th, 1921—Abstract. *Radioélectricité*, 1, p. 145D, June, 1921—Abstract.)

If an auto-heterodyne set is accurately tuned to the incoming C.W. signal, there is a range over which it pulls into step with the signal and gives no beats. The oscillatory current is thereby increased as is indicated by the decreased reading on a D.C. ammeter in the anode circuit. This latter can thus be used as an indicator of the signal and is undisturbed by other C.W. signals of another frequency or by spark signals. The instrument is too sluggish to respond to acoustic frequencies. Loose coupling gives sensitiveness and a wide range ; tight coupling, a narrow range and great freedom from interference. The paper contains a very elaborate investigation of the phenomenon.

2977. **Von Wysiecki** [E. F. Huth Gesellschaft]. Thermionic Receiving Systems. (*British Patent* 149196, July 12th, 1920. Convention date May 5th, 1919. Patent not yet accepted.)

In order to present radiation for the receiving aerial the last valve alone of the cascade series is used as the local oscillation generator.

2978. **S. Loewe.** Wireless Receiving Apparatus. (*British Patent* 149199, July 12th, 1920. Convention date October 12th, 1918. Patent not yet accepted.)

A rejector circuit consisting of an inductance and a condenser in parallel is connected in the plate circuit of a series of thermionic valves. For heterodyne reception local oscillations are produced in and confined to the last valve in the series. One suggested arrangement is indicated in Fig. 6. D represents the rectifying detector and T the receiving telephone.

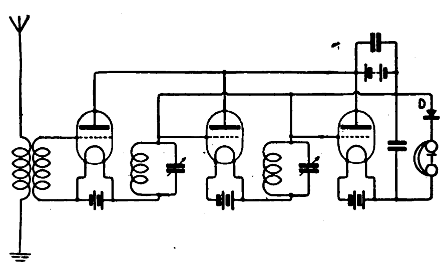

FIG. 6.

2979. **E. F. Huth.** Wireless Receiving Apparatus. (*British Patent* 149208, July 12th, 1920. Convention date April 29th, 1919. Patent not yet accepted.)

The local oscillator in a heterodyne receiving apparatus is connected to the receiving circuit through an intermediate aperiodic circuit with the object of attaining equality of amplitude of the received and the local oscillations.

2980. **E. F. Huth.** Wireless Receiving Apparatus. (*British Patent* 149209, July 12th, 1920. Convention date December 14th, 1917. Patent not yet accepted.)

Comprises an arrangement of thermionic valves for heterodyne receiving which can readily be converted for transmitting either simple or musically modulated radiation. Switches are arranged for easily effecting the change-over from reception to transmission.

2981. **S. Loewe** [E. F. Huth Gesellschaft]. Thermionic Valve Amplifying Apparatus. (*British Patent* 149217, July 12th, 1920. Convention date June 11th, 1917. Patent not yet accepted.)

In a thermionic amplifier of the type in which the amplified impulses in the anode circuit are retroactively returned to the grid to obtain further amplification, the anode circuit is coupled to an aperiodic circuit of the receiver—such as the untuned output circuit of the rectifier. The highest possible degree of amplification is stated to be obtained in this manner without the valve oscillating.

2982. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 150701, August 30th, 1920. Convention date September 6th, 1919. Patent accepted May 5th, 1921.)

In a thermionic valve receiver incoming oscillations are interrupted at audio frequency by an interrupter inserted either between the antenna and a thermionic valve or between the valve and the telephone receiver.

2983. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Receiving Wireless Signals. (*British Patent* 159603, December 1st, 1919. Patent accepted May 1st, 1921.)

For the reception of C.W. signals without heterodyne or tikker, or of signals having a very low group frequency, the detecting valve is included in one arm of a balanced Wheatstone bridge. The bridge is fed from an acoustic frequency source, and the telephones are joined in the " galvanometer " arm of the bridge.

2984. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 147701, July 8th, 1920. Convention date May 2nd, 1916. Patent not yet accepted.)

In a system for receiving C.W. of frequency n, the received oscillations excite an alternator or E.S. machine having a natural frequency of N. Two frequencies of $N + n$ and $n - N$ are thus produced. These interfere in the detector circuit giving beats of frequency $2N$.

2985. **A. van T. Day.** Wireless Signalling Apparatus. (*British Patent* 148380, July 9th, 1920. Convention date July 17th, 1916. Patent not yet accepted.)

Relates to : (1) Receiving systems using heterodyne reception of the same or different frequency with duplex valve or other detectors ; (2) telephony systems in which the local (heterodyne) energy is maintained exactly in synchronism with the received carrier wave by the action of the carrier wave itself ; (3) methods of reducing atmospherics in which the receiving aerial is detuned so that the atmospheric produces a beat note of higher frequency than the signal ; (4) multiplex working in which one or more messages are sent by varying the phase, and the others by varying the amplitude of the transmitted wave.

2986. **A. K. Macrorie** and **W. A. Appleton.** Wireless Receiving Apparatus. (*British Patent* 162770, February 2nd, 1920. Patent accepted May 2nd, 1921.)

For receiving C.W. signals a " damping-valve " is coupled to the circuit—such as to the anode circuit of the last valve in a H.F. amplifier—and has its grid controlled by a valve oscillating at an audible frequency so that the amplitude of the received energy is thus varied at an audible frequency.

2987. **A. K. Macrorie** and **S. H. Long.** Wireless Receiving Apparatus. (*British Patent* 162771, February 2nd, 1920. Patent accepted May 2nd, 1921.)

A valve is arranged to generate low frequency currents and is prevented from oscillating by the application of a suitable potential to its grid. On the receipt of the signal an auxiliary valve alters the grid potential of the low frequency valve and causes it to oscillate at an acoustic frequency.

2988. **R. B. Goldschmidt.** Receiving Apparatus. (*French Patent* 508782, January 20th, 1920. Published October 22nd, 1920.)

The specification describes apparatus for putting the antenna into and out of operative relation with the receiver at a frequency equal to the trains of waves to be received. For transmitting a uniform succession of trains of waves is ensured by the use of a commutator inserted in the primary circuit of the induction coil or connecting the antenna with the oscillation circuit. Multiplex working may be effected by arranging that the commutators at the transmitting and receiving stations serve also as distributors. For further particulars, see *British Patent* 15082/14.

2989. **Gesellschaft für drahtlose Telegraphie.** Wireless Signalling. (*British Patent* 157403, January 10th, 1921. Convention date August 29th, 1919. Patent not yet accepted.)

In a method of receiving continuous waves a thermionic valve is caused to oscillate at a low frequency whilst acting also as a high-frequency amplifier through an independent circuit.

2990. **C. T. Hughes** and **L. B. Turner.** Wireless Telegraph Receivers. (*British Patent* 157607, November 14th, 1919. Patent accepted January 27th, 1921.)

A receiving system specially suitable for short wave continuous wave reception. A three-electrode valve oscillating at audio-frequency modulates the received signals before rectification.

2991. **Société Française Radioélectrique.** Wireless Telephony. (*British Patent* 147836, July 9th, 1920. Convention date February 24th, 1917. Patent not yet accepted.)

Relates to the use of a heterodyne for receiving wireless telephony, the beat frequency being inaudible and preferably zero.

2992. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 147852, July 9th, 1920. Convention date April 9th, 1914. Patent not yet accepted.)

A heterodyne is coupled to the plate circuit of a valve amplifier.

2993. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 148162, July 9th, 1920. Convention date October 15th, 1915. Patent accepted July 21st, 1921.)

C.W. receiving apparatus comprising a " tikker " arrangement.

2994. **H. J. Round.** Heterodyne Reception. (*Radio Review*, 2, pp. 220—223, April, 1921. *Science Abstracts*, 24B, p. 316, June 30th, 1921—Abstract.)

2995. **J. V. L. Hogan.** The Heterodyne Receiver. (*Electric Journal*, 28, pp. 116—119, April, 1921.)

A general description of heterodyne methods.

2996. **M. C. Batsel.** Continuous Wave Radio Receiver. (*Electric Journal*, 28, pp. 136—141, April, 1921.)

Describes various arrangements of valve receiving amplifying apparatus.

2997. **L. M. E. Clausing.** Reception of 200 Metre Signals by Means of a Loop and Armstrong Super-heterodyne. (*Q.S.T.*, 5, pp. 24—26, August, 1921.)

2998. **J. Scott-Taggart.** Wireless Telegraphy. (*British Patent* 165115, August 18th, 1919. Patent accepted June 30th, 1921.)

An electric discharge device having two or more control electrodes, for use in relays and radio receiving systems, for example, a thermionic valve having a cathode, two grids, and an anode, has input circuits supplied with varying current or potential connected to each of the grids, thus producing a resultant effect on the anode or main supply circuit.

2999. **Marconi's Wireless Telegraph Co., Ltd.** Receiving Heterodyne Arrangement. (*French Patent* 512781, March 30th, 1920. Published January 31st, 1921.)

The phase of the beat current in a heterodyne receiving system is adjusted by varying the phase of the heterodyne current or of the signalling waves so that the beat current is brought into phase with, or opposition to, a second current of the same frequency. The system may be utilised for cutting out undesired signals by employing two receiving aerials spaced apart to produce phase displacements in the signal currents. (See also *British Patent* 149435 in the name of **H. J. Round.**)

3000. **H. de A. Donisthorpe.** A Continuous Wave Receiver. (*Model Engineer*, 45, pp. 313—314, October 13th, 1921.)
Circuit diagrams are given for various arrangements of C.W. receivers.

3001. **L. R. Felder.** Rectifying A.C. for Vacuum Tubes. (*Radio News*, 3, p. 200, September, 1921.)

(5) RELAYS, RECORDERS AND AUTOMATIC CALLING APPARATUS.

3002. **A. A. Campbell Swinton.** Wireless Telegraphic Printing on the Creed Automatic System. (*Wireless World*, 8, pp. 641—648, December 11th, 1920. *Times*, p. 9, November 17th, 1920. *Elektrotechnische Zeitschrift*, 42, p. 160, February, 1921. *Everyday Science*, 2, pp. 682—684, April, 1921—Abstract. *Radio News*, 2, pp. 600—601, and 640—642, March, 1921—Abstract.)
See RADIO REVIEW, 2, pp. 37—38, January, 1921.

3003. **A. A. C. Swinton.** Wireless Telegraphy and Telephony. (*Journal of the Royal Society of Arts*, 69, pp. 24—36, December 3rd, 1920. *Telephone Engineer*, 24, pp. 13—17, February, 1921—Abstract. *Electrician*, 85, p. 631, November 26th, 1920—Abstract. *Technical Review*, 8, p. 167, February 15th, 1921—Abstract. *Nature*, 106, p. 422, November 25th, 1920—Abstract. *Engineering*, 110, p. 678, November 19th, 1920—Abstract.)
See RADIO REVIEW, 2, pp. 37—38, January, 1921.

3004. **E. H. Eckhardt** and **J. C. Karcher.** A Chronographic Recorder of Radio Time Signals. (*Journal of the Washington Academy of Sciences*, 11, pp. 303—311, July 19th, 1921. Also *Telegraph and Telephone Age*, 39, p. 175, April 16th, 1921—Abstract. *Physical Review*, 18, pp. 150—151, August, 1921.)
Paper read before the Philosophical Society of Washington, March 26th, 1921, and before the American Physical Society, April, 1921, discusses the general problems of recording wireless signals and describes with diagrams the arrangements developed at the Bureau of Standards. This method utilises a valve receiver acting as a trigger relay, the change in anode current serving to operate the relay magnets. The article concludes with a bibliography of the subject.

3005. **H. Abraham** and **R. Planiol.** On the Use of Baudot Telegraph Apparatus in Radio Work. (*Comptes Rendus*, 172, pp. 1170—1172, May 9th, 1921. *Revue Scientifique*, 59, p. 283, May 28th, 1921—Abstract. *Journal Télégraphique*, 45, pp. 107—108, June 25th, 1921—Abstract. *Telegraph and Telephone Age*, 39, p. 301, July 1st, 1921. *Science Abstracts*, 24B, p. 362, Abstract No. 746, July 30th, 1921—Abstract. *Genie Civil*, 78, p. 442, May 21st, 1921—Abstract.)
A brief description is given of the apparatus used in some recent tests between Paris and Nogent-le-Rotron. The transmission from Paris, using not more than 3 amps in a small aerial, was controlled automatically by the Baudot apparatus; while for reception two sharply-tuned circuits were used with a frame aerial, a high-frequency resistance-coupled amplifier, a detector and a low-frequency amplifier. The output from the amplifier operated the Baudot relay directly without the use of any heterodyne. Automatic retransmission over the land lines back to Paris was also accomplished.

3006. **B. S. T. Wallace.** Morse Printing of Wireless Signals. (*Wireless World*, 8, pp. 768—770, February 5th, 1921. *Electrical World*, 77, p. 839, April 9th, 1921—Abstract.)

3007. **R. E. Hall.** Signalling Systems. (*British Patent* 144250, February 2nd, 1920. Convention date May 31st, 1919. Patent accepted April 28th, 1921.)
Deals with a hot wire relay for controlling a recording telegraphic receiver.

3008. A New German Recording Device. (*Radio News*, 2, p. 691, April, 1921.)
Describes an arrangement of amplifier using the supersonic heterodyne principle to obtain sufficient amplification for the operation of the relay by the last valves.

3009. **P. R. Coursey.** Relays and Recorders. (*Wireless World*, 8, pp. 761—763, February 5th, 1921. *Radioélectricité*, 1, p. 113D, April, 1921—Abstract.)
A summary of some of the early patterns of wireless recording apparatus.

3010. **Gesellschaft für drahtlose Telegraphie.** Wireless Recording Apparatus. (*British Patent* 148992, July 12th, 1920. Convention date February 8th, 1916. Patent not yet accepted.)

A direct current relay for a recording device is operated by wireless signals by means of the interposition of a thermionic tube, the grid potential of which is such that without external influence no current flows through the plate circuit. The rectified current from the detector is amplified by a series of valves, the last one of which is designed for larger currents. The grid potential of this last tube is adjusted by a potentiometer so that normally no plate current flows through the relay.

3011. **A. F. Sykes.** Sound Recording Apparatus. (*British Patent* 160223, November 18th, 1919. Patent accepted March 18th, 1921.)

Deals with apparatus for recording sounds on a wax cylinder with electrical means for distorting the wave form to neutralise mechanical resonance and other existing causes of distortion.

3012. **Gesellschaft für drahtlose Telegraphie.** Code Telegraphy. (*British Patent* 147432, July 7th, 1920. Convention date November 9th, 1916. Patent accepted July 14th, 1921. *Engineer*, 132, pp. 205—206, August 19th, 1921—Abstract.)

A recording arrangement in which a thread is utilised in place of the usual tape.

3013. **H. J. J. M. de R. de Belleseize.** Wireless Type-printing Telegraph. (*British Patent* 158556, January 22nd, 1921. Convention date January 22nd, 1920. Patent not yet accepted.)

An adaptation of the Baudot system to wireless working. In order to secure secrecy the impulses that build up a letter are set out from distributor segments chosen in a predetermined irregular fashion.

3014. **R. E. M. Pénot.** Recorder. (*French Patent* 507129, December 6th, 1919. Published September 6th, 1920.)

The invention describes an automatic recorder which may be employed for recording wireless telegraphy signals. The received currents act on the recording apparatus through a distributor, a relay and a regulator.

2. Books.

EXPERIMENTAL WIRELESS STATIONS. By Philip E. Edelman, E.E. (London: *Henry Frowde and Hodder & Stoughton*. New edition, 1920. Pp. x + 392. 7¼″ × 5″. With 167 illustrations. Price 16*s*. net.)

This book is designed primarily as a guide to the American radio amateur who wishes to build an experimental wireless station that shall be based on a sound design. It is however more than a mere "how-to-make-it" book, as it contains several chapters devoted only to general theory and descriptive matter of the usual text-book type. There are twenty-seven chapters in the present edition, which incorporate the material forming the earlier editions, the supplementary matter appended to the end of the 1916 edition, and much additional matter relating to vacuum tubes, including many circuit diagrams for receiving.

The transmitting section of the book has also been brought up to date by the addition of a short description for building a radiotelephone transmitter.

The general appearance of the book has been much improved in this edition, and the illustrations have been prepared with greater care. There is however still room for further improvement in the printing and setting out of the numerical examples that are given throughout the book. A useful classified list of U.S. radio patents is given at the end of the volume, but this has not been revised beyond 1916, but nevertheless forms a good record of the historical development of the subject.

P. R. C.

HIGH-FREQUENCY APPARATUS. By Thomas S. Curtis. (London: *Page & Co.* 1921. Pp. 269. 7½″ × 5″. With 150 diagrams. Price not stated.)

While high-frequency currents have their many useful and practical applications, relative to which there is a considerable literature, there is another class of writing which is concerned

more with the spectacular aspect of electrical phenomena at high frequencies, and with the best means of exhibiting such phenomena. The present book, the first English edition of an American work, is another addition to this latter class of literature. It describes first the fundamental characteristics of alternating currents, and then points out the applications of such currents when of high frequency. Subsequent chapters deal with the high-potential transformer, or induction coil; the oscillation condenser; the spark gap; oscillation transformers; induction coil outfits for battery current; kicking-coil apparatus; ½-kW transformer outfit; quenched gap apparatus; physician's portable apparatus and office equipment; and hot-wire meter construction. Three chapters are devoted to the applications of high-frequency current to plant culture, giving constructional details of experimental apparatus; while the remaining chapters deal with the building and operation of large high-frequency apparatus for stage demonstrations, and also with the construction of a welding transformer as an adjunct to stage entertainments with high-frequency currents.

P. R. C.

Books Received.

RADIO QUESTIONS AND ANSWERS ON GOVERNMENT EXAMINATION FOR RADIO OPERATOR'S LICENCE. By Arthur R. Nilson, Assoc.M.I.R.E. (New York: *McGraw-Hill Book Company, Inc.* London: *McGraw-Hill Publishing Co., Ltd.* 1921. Pp. ix + 86, 7¼ in. × 5 in. With 43 diagrams. Price 5*s.* net.)

LEXIQUE TECHNIQUE ANGLAIS-FRANÇAIS. By Lieut. G. Malgorn, in collaboration with M. Desmarets. (Paris: *Gauthier-Villars et Cie.* 1920. Pp. xxi + 216. 7¼ in. × 5 in. Price 10 fr. net.)

Correspondence.

"CHOKE CONTROL" MODULATION IN RADIOTELEPHONY.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—My attention has recently been directed to British Patent Specification No. 133366 of June 28th, 1918, of the Western Electric Company in which is described the well-known "choke control" method of modulation in radiotelephony. Various authors have wrongly attributed this system to Heising. As a proof thereof, suffice it to quote part of my French Patent No. 21855 of November 30th, 1916* in which this system is described in its most elaborate form and as it was used by the British and American Signalling Corps during the war:—

> "In certain wireless telephone diagrams the voltages obtained by the action of the voice on the microphone are amplified by means of thermionic tubes and then impressed on the high-frequency cathode tube generator which energises the antenna. These voltages may be impressed on either the grid or the plate circuit of the generator.
>
> "The object of the present invention is to realise an arrangement whereby a part or the whole of a single source of direct current may be used to energise both the microphone current amplifying tubes and the generator tubes in accordance with the general idea of a common battery put forth in the main patent.
>
> "Figure 1 shows four tubes, 1, 2, 3, 4, the filaments of which are brought to incandescence by battery 5, all the anodes being fed off a common battery 6.
>
> "Tubes 1 and 2 are used to amplify the microphone current. The microphone current originating in the circuit comprising the microphone, 8, and the battery, 9, is communicated to the grid and negative pole of the filament of tube 1 through the transformer, 7. Transformer 10 permits of this current undergoing a second stage of amplification through tube 2. The resulting amplified microphone voltages are introduced in the plate circuit of the parallel-connected high-frequency generating tubes 3 and 4 through the transformer 11.
>
> "The high-frequency generator includes, in accordance with a known diagram which

[* The patent referred to is the fifth addition (21855) to French Patent No. 512295.—ED.]

is only shown by way of example, a primary winding 12, and auxiliary winding 13, connected to the grids and filaments, and a secondary winding 14, which feeds the antenna 15.

"The secondary winding of the transformer 11 should preferably be shunted by a small capacity in order to create a by-path for the high-frequency current without appreciably impairing the low-frequency working.

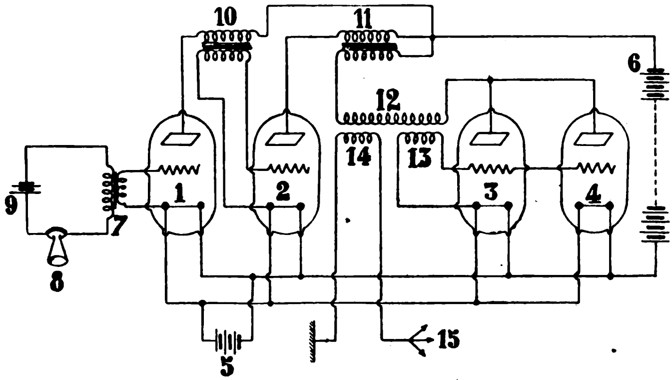

FIG. I.

Reproduction of Diagram from Patent Specification.

"If the speech-amplifying tube filaments are heated to the same degree as those of the generating tubes, the amplified microphone voltages obtained at transformer 11 may be of the order of that of the battery 6 and consequently it is easily seen that the arrangement described permits of the efficient working of the generating tubes 3 and 4 and this even with a relatively small voltage from battery 6.

"*Transformer* 11 *may amount to an auto-transformer or a mere choke coil. In view of the fact that a relatively important steady current flows through its winding, it will be preferable to leave an air-gap in its magnetic circuit.*

"The elements of the battery 9 may economically be constituted by a portion of either the battery 5 or 6."

Trusting the above may serve to dissipate a prevalent error.

MARIUS LATOUR.

Paris,
December 31*st*, 1921.

OPTIMUM WAVELENGTH.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—Mr. Turner in his discussion of the question of optimum wavelength in the October number of the REVIEW appears to neglect a factor which is of primary importance where continuous communication is demanded. This is the change in degree of variability of signal with wavelength and distance. It is of course true that the atmospheric disturbances increase rapidly with the wavelength, which prevents the average reception from following the usual optimum wavelength formula. But, as a matter of fact, the variability in signal decreases even more rapidly with the wavelength than the disturbances increase, so that for great distances the advantages of long waves for continuous communication are even greater than the formula indicates. This fact has been tested in several years of trans-Atlantic observations, and also between Darien and Washington (2,000 miles). In this last case a 4,000 metre wave was found useless for regular day transmission, while waves from 6,000 metres to 12,000

metres gave fairly satisfactory communication except in the season of the worst disturbances.

Of course if fairly regular night work is all that is required, relatively short waves will give the most economical service even over great distances.

L. W. AUSTIN.

U.S. Naval Radio Research Laboratory,
Washington,
January 6th, 1922.

TRANSMISSION OF WIRELESS SIGNALS BETWEEN TOULON AND TAHITI.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—The account of the reception experiments on the *Aldebaran*, in the December number of the REVIEW, is full of interesting long-distance data.

The most remarkable fact shown in the curves of the paper is the effect of the Red Sea on the intensity of the signals. The day reception follows our formula fairly well as far as Port Said. Then, as the ship enters the Red Sea, there is a relative increase in observed intensity which becomes an actual upward bend in the curve in the case of the Lyons signals. The high values continue through the Red Sea and also in the Indian Ocean, as though the strip of water between the two desert land areas acts as a guiding conductor for the waves, and its outlet becomes as it were a new source. This phenomenon is well-known in short wave communication, especially with airplanes where a strengthening of signal is always observed when the plane approaches a river extending in the direction of the transmitting station. Such conditions may sometimes produce better transmission over land than even over salt water.

In connection with the *Aldebaran's* observed intensity values, experiments on the apparent direction of Lyons at various points in the Indian Ocean would be of interest.

I must object to the statement that the transmission formula has been verified only up to 3,700 km. As a matter of fact, several thousand measurements, extending over seven years have been taken in our laboratory in Washington on the European stations, especially Nauen (6,600 km), and the mean difference between the average observed and calculated values is hardly more than 30 per cent., while the accuracy of our present method of measurement, by comparison with signals from small currents in a sending antenna of known constants one or two wavelengths away, cannot be questioned. To me the accuracy of the formula for wavelengths of from 12,000 metres to 24,000 metres, and for distances of from 6,000 to 7,000 km is much better established than for 1,000 metre waves at a distance of 1,000 km. I do not feel that Professor Vallauri's observations, extending over only a single period of twenty-four hours, in any way invalidate this conclusion. I am also sorry to see that in the article the formula is given in its old form

$$I_R = 4{\cdot}25 \frac{I_s h_s h_R}{\lambda d} \epsilon^{-ad/\sqrt{\lambda}}$$

with constant receiving resistance, instead of in its present usual form,

$$I_R = 120\pi \frac{I_s h_1 h_2}{\lambda d R} \epsilon^{-ad/\sqrt{\lambda}}$$

L. W. AUSTIN.

U.S. Naval Radio Research Laboratory,
Washington,
January 6th, 1922.

ERRATA.

Pages 34 *and* 35. The name of the radio station should be Iwaki.
Page 51, *Abstract No.* 2933. *For* **F. W. B. Gill** *read* **E. W. B. Gill.**

THE RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. III MARCH, 1922 No. 3

Editor:
PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.

Assistant Editor:
PHILIP R. COURSEY, B.Sc., F.Inst.P., A.M.I.E.E.

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SUBSCRIPTION RATES.—£3 per annum, post free. Single copies, 5/-, or post free, 5/3.

Vol. III. No. 3 | Registered at the G.P.O. for transmission by Magazine Post to Canada and Newfoundland. | MARCH, 1922

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THE
RADIO REVIEW

VOL. III MARCH, 1922 NO. 3

Editorial.

The "Radio Review."—We regret to have to inform our readers that after this month it will no longer be possible to issue the RADIO REVIEW as a separate publication devoted to the scientific developments of radio communication. The continued excessive cost of printing has rendered necessary this suspension of the publication, in spite of the recently increased subscription rate.

In order, however, to retain in this country a medium for the publication of articles of a technical nature dealing with the developments of radio apparatus, and giving the results of research and experimental work, arrangements have been made for the incorporation in the pages of the *Wireless World* of some of the characteristic features of the RADIO REVIEW. On and after April 1st, the former publication will be issued weekly, and it is intended to devote a few pages of each issue to articles and other matter of the type that has in the past been published in the RADIO REVIEW. It is hoped that as many as possible of our past contributors and readers will avail themselves of these facilities for the publication of articles and other matters of interest to the radio engineer, research worker and student of the technical development of radio communication in its various branches.

The Amateur Licence Problem.—In this and in all other countries the problem of the licensing of the radio amateur is becoming ever more acute. So long as the amateur is content to receive and to employ only such methods as do not radiate any appreciable power, there can be little, if any, objection to an unlimited increase in their number. Experimenting in the reception of radio signals must have considerable educational value and is therefore highly desirable. The construction of apparatus and the reading and discussion of papers at the many wireless societies must do much to disseminate a knowledge of practical physics among thousands who would not otherwise have obtained this knowledge. It will, moreover, guarantee an immediate supply of partially trained operators in case of war, and operators who are keenly interested in their work. Since the possession of radio apparatus, and especially of an antenna, puts it into one's power to transmit electromagnetic waves and cause interference, and also because of the desirability of ensuring some degree of privacy for messages transmitted by wireless, it appears essential that some authority should exercise control by the granting of licences.

To cover the expense thus involved it is improbable that any amateur would object to the payment of a small fee. At one time, however, the British authorities demanded a fee of three guineas from any clockmaker for the privilege of being allowed to pick up from the ether the time signals sent out from the French or German wireless stations. This demand, which is rather suggestive of Alice in Wonderland, was ultimately withdrawn, and an Englishman with a receiving licence is now at liberty to pick up the time signals which are sent out from Paris, Moscow, and other centres, and to regulate his chronometer with mixed feelings of gratitude and shame by means of this second-hand Greenwich time.

But the amateur, even if he is content to receive, is not yet satisfied ; for some time he has been asking for special signals to be sent out for his benefit. This demand has arisen in consequence of the great improvements in radiotelephony, and the desire to pick up speech and music rather than the prosaic Morse signals. The amateurs have now persuaded the authorities to give their permission for a central transmitting station to send out programmes of music similar to those given out at present from the Hague and from Paris.

There can be no objection to this course so long as no interference is caused with radiotelegraphy and telephony of a more serious character. There is no doubt a much greater fascination in picking up speech and music because of its direct appeal to the senses and of its varied character giving much greater scope to the receiver in gradually improving both its loudness and its quality. It is also a much newer field with greater prospects of discovery and development. Some cynics have suggested, however, that the post-war radio amateur is made of poorer stuff than the type of ten years ago and cannot be bothered to learn the Morse code, but needs to be amused in order to maintain his interest in his hobby, for there is surely no shortage to-day of wireless signals of every description for his delectation. The proceedings at any of the meetings of the various wireless societies are sufficient refutation of this suggestion.

Theoretical and Practical Aspects of Low Voltage Rectifier Design when employing the Three-electrode Vacuum Tube.

By R. D. DUNCAN, Jun.

Chief Engineer, U.S. Signal Corps Research Laboratory, Bureau of Standards.

(*Concluded from page* 71.)

Percentage Amplitude of " Ripple " Voltage over Load Resistance. —On the assumption that the maximum amplitude of the alternating component of the condenser voltage, which in this case is also the voltage

applied to the load resistance, is equal to one-half of the total variation, this quantity is given by

$$\Delta V_{r0} = \frac{\Delta V_c}{2} = (E_0 - V_0)\frac{1-K}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The ratio of equation (11) to (6) is a measure of the percentage fluctuation of the final load voltage. Thus,

$$\mu = \frac{\Delta V_{r0}}{V_{dc}} \times 100 = \frac{1-K}{1+K} \times 100 \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

If an inductance is connected in series with the load resistance the voltage given by equation (11) is impressed across both it and the resistance. The resulting maximum current which will flow will be of the form

$$\Delta I_{r0} = \frac{E_0 - V_0}{\sqrt{r^2 + \omega^2 L^2}} \cdot \frac{1-K'}{2} \quad . \quad (13)$$

The voltage developed over the resistance r will then be,

$$\Delta V_{r0} = \frac{r(E_0 - V_0)}{\sqrt{r^2 + \omega^2 L^2}} \cdot \frac{1-K'}{2} \quad . \quad (14)$$

As before the amount of voltage fluctuation is determined from the ratio of equations (14) to (6), *i.e.*,

$$\mu = \frac{\Delta V_{r0}}{V_{dc}} \times 100 = \frac{r}{\sqrt{r^2 + \omega^2 L^2}} \cdot \frac{1-K'}{1+K'} \times 100 \quad . \quad (15)$$

In equations (13), (14) and (15),

$\omega = 2\pi f$ for half-wave rectification,

$\omega = 4\pi f$ for double wave rectification,

where f represents the frequency of the supply voltage.

As noted from equations

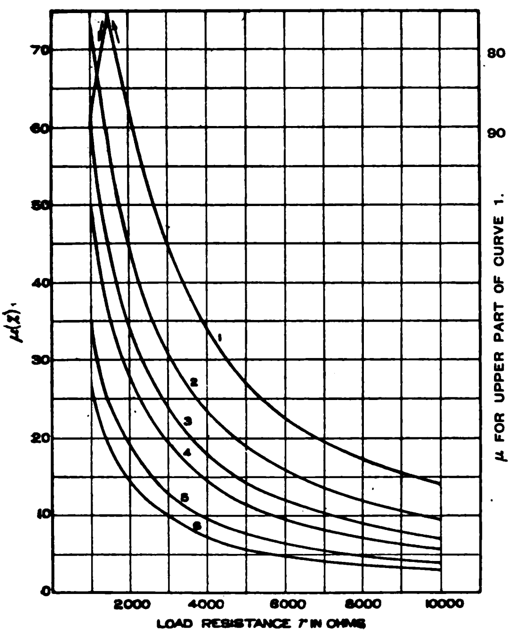

FIG. 6.—HALF-WAVE RECTIFICATION.

Frequency = 60 ~; $t_2 - t_1 = 1/87$ sec.
Inductance $L = 0$.

Curve No.	Capacity C.
1	4 μ F
2	6 μ F
3	8 μ F
4	10 μ F
5	15 μ F
6	20 μ F

(3), (8), (12), and (15) μ, the percentage ripple voltage, is a function of the circuit constants and of K or K', themselves functions of the time interval $t_2 - t_1$ and also of the circuit constants. Values of $t_2 - t_1$ were determined from a large number of oscillograms taken with different circuit conditions; a representative number are shown in Figs. 4 and 5. As a result of this oscillographic study and of transmission and reception tests, it was determined that with values of smoothing condensers and inductances which would give satisfactory telephonic and telegraphic operation as regards suppression of the ripple voltage, the following values of $t_2 - t_1$ are effective:

For 60 cycle operation:

Half-wave rectification, $t_2 - t_1 = 1/87$ second.

Double wave rectification, $t_2 - t_1 = 1/250$ second.

Based on these average values the curves of Figs. 6, 7, 8 and 9 were computed. In Figs. 6 and 7 are plotted values of μ as a function of the circuit constants, for both half-wave and double wave rectification. In Figs. 8 and 9 are plotted values of the factor $\frac{\sqrt{2}}{1+K}$ appearing in equation (7), for the same circuit conditions.

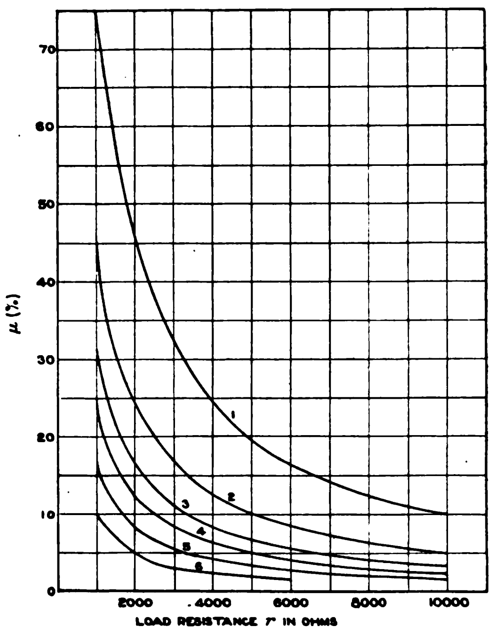

FIG. 7.—DOUBLE-WAVE RECTIFICATION.

Frequency = 60 ~; $t_2 - t_1 = 1/250$ sec. Inductance $L = 0$.

Curve No.	Capacity C.
1	2 μ F
2	4 μ F
3	6 μ F
4	8 μ F
5	12 μ F
6	20 μ F

A comparison of the curves shows the marked reduction in the values of μ obtained with double wave rectification as against half-wave rectification. The advantage of employing a large smoothing capacity, particularly for low value load resistances, is also manifest. As illustration, where the frequency is 60 cycles per second, for a resistance of 3,000 ohms, which is a representative value, with a condenser of 4 microfarads, the values of μ as obtained from Figs. 6 and 7

are respectively, for half-wave and double wave rectification, 45 per cent. and 17 per cent. It is interesting to note that with a frequency of 500 cycles per second, these two figures are reduced to 7·5 per cent. and 2·5 per cent. respectively.

In the experimental work it has been found unnecessary to resort to the use of the multi-mesh filter circuit to obtain the desired degree of smoothing of the rectified voltage.

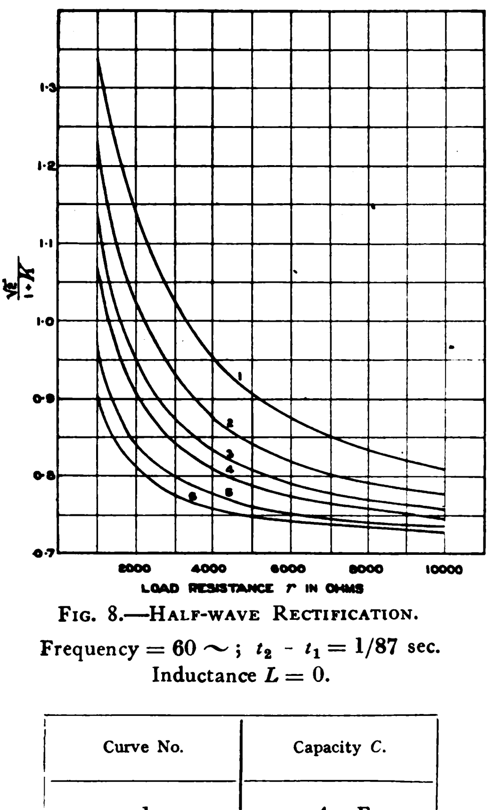

FIG. 8.—HALF-WAVE RECTIFICATION.

Frequency = 60 $\sim$; $t_2 - t_1 = 1/87$ sec.
Inductance $L = 0$.

Curve No.	Capacity C.
1	4 μ F
2	6 μ F
3	8 μ F
4	10 μ F
5	15 μ F
6	20 μ F

The factor $\frac{\sqrt{2}}{1+K}$ which appears in equation (9) and which is plotted in Figs. 8 and 9, when proper account is taken of maximum voltage drop in the rectifier tube, determines the value of the effective transformer secondary voltage, in terms of the average rectified voltage. From the curves it is observed that with increasing capacity and resistance values, the lower is this effective voltage required for a given rectified voltage. The limit to this of course is the physical size which the large value condenser will assume and the fact that the magnitude of the resistance is determined by the load characteristics and in general may not be varied at will.

Determination of the Voltage Consumed by the Rectifier Tube.—The voltage consumed within the rectifier tube, *maximum* value V_0, has been determined experimentally by means of the oscillograph, calibrated in terms of voltage, as previously explained. Values of V_0 were so obtained for both half-wave and double-wave rectification and for different load conditions.

V_0 is determined largely in value by the current flowing through the tube, and as shown in the experimental portion of this paper, this latter quantity bears a very direct relation to the direct current in the load resistance. To

identify the voltage V_0 with the tube, relations have been determined between it and D.C. plate voltage which produces a direct plate current (plate and grid connected) equal in value to the R.M.S. tube current which flows under load conditions. By this means the voltage drop is based upon, and may be determined from the D.C. plate current—plate voltage characteristic (plate and grid connected) of the tube, which is easily obtainable.

The following approximate relations, representing average values, were determined to hold for a frequency of 60 cycles per second, and with different types of coated filament rectifier tubes. Though not entirely general, they were found to have sufficient accuracy for design purposes.

Half-wave rectification :

$V_0 = 1{\cdot}5 \times$ (D.C. plate voltage) . . . . (16)

Double wave rectification :

$V_0 = 1{\cdot}3 \times$ (D.C. plate voltage) . . . . (17)

In using these relations the R.M.S. tube current is first determined, as explained in the second section following; this value of current is then referred to the D.C. plate current characteristic of the tube obtained with the plate and grid connected, and the corresponding D.C. plate voltage noted; the value of V_0 is then obtained from the above relations.

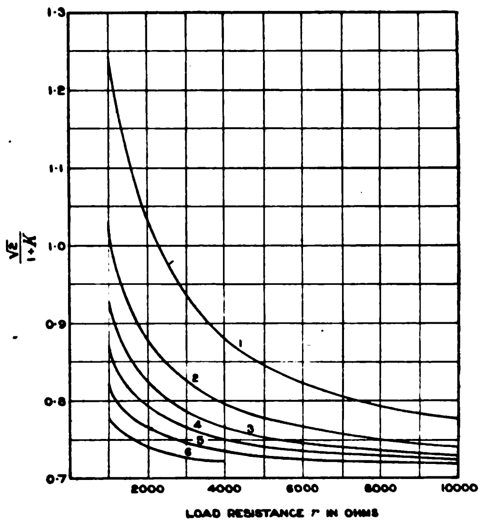

FIG. 9.—DOUBLE WAVE RECTIFICATION.

Frequency = 60 ~ ; $t_2 - t_1 = 1/250$ sec.
Inductance $L = 0$.

Curve No.	Capacity C.
1	2 μ F
2	4 μ F
3	6 μ F
4	8 μ F
5	12 μ F
6	20 μ F

Voltage Regulation.—The regulation of the rectified voltage enters into the design as from it is determined the factor of safety which must be allowed in the insulation design of the smoothing out capacity. With normal values of the load resistance the rectified voltage is as given by equation (6) ; with very large values of this resistance, or with an infinitely large resistance, such as would be the case with the load disconnected, the rectified voltage will rise to a higher value and will become approximately equal to the peak value, E_0, of the applied voltage. The smoothing out capacity must therefore be constructed to withstand this latter voltage.

Current and Power Delivered by Transformer Secondary.—The current flowing through the rectifier tube is determined in value by the tube resistance, the type of load and by the amplitude of the applied voltage; the root mean square (R.M.S.) value of this current is that which the secondary of the transformer must be designed to carry. In the hard type of tube the full saturation current may be obtained and hence during the major portion of the time the current is flowing it is fixed at this value. With the coated filament tube, due to the fact that the saturated condition is not obtainable for continuous operation, the current at every instant during its time of flow, is varying. In the latter case were the exact current function known its R.M.S. value could be computed, a result, however, which would hold only for a given condition of loading and would have no general significance. Furthermore, with a given condition of loading, the current will have a different R.M.S. value with half-wave and with double wave rectification, due to the difference in time of charge and discharge of the condenser for the two cases. A determination, therefore, of a root mean square current function which will hold for tubes of different characteristics and for different conditions of loading, though theoretically possible, would have limited practical value.

The same remarks apply when it is attempted to compute the power which will be delivered by the transformer secondary, since this quantity is a function of the products of the instantaneous values of the transformer secondary current and voltage.

Experimental methods have been resorted to for the solution of this phase of the problem. In general the quantities that are initially known, and upon which the design of the rectifying apparatus is based, are, the final load resistance, and the voltage and current requirements of the same; from these the rectified or D.C. power output is determined. On the other hand the transformer must be designed to supply a certain power at a definite terminal voltage and with a definite current flowing. An empirical relation, therefore, between the rectified power developed, *i.e.*, the power expended in the final load resistance and the power furnished by the secondary of the transformer, and between the direct current and R.M.S. transformer secondary current would permit of the immediate determination of these two important design quantities from the known load requirements.

By experiment the following relations have been established, which hold for the coated filament type of three-electrode (plate and grid connected) rectifier tube, when working in the infra-saturated condition. The numerical values given represent the average of a number obtained with different load conditions.

60 *Cycles.*

Half-wave rectification :

R.M.S. transformer secondary current $= 2{\cdot}00 \times$ (direct current flowing in final load resistance) . . . . (18)

$$\frac{\text{Power expended in final load resistance}}{\text{Power delivered by transformer secondary}} \times 100 =$$

$=$ rectification efficiency $= 60$ per cent. . . . . (19)

Double wave rectification :

R.M.S. transformer secondary current = 0·93 × (direct current flowing in final load resistance . . . . (20)

Rectification efficiency = 70 per cent. . . . . (21)

Illustration of Use of the Design Equations.—As an illustration of the method of use of the design equations and relations let it be required to design a transformer which, operating in conjunction with a rectifier tube of known characteristics, will develop a power of 200 watts in a load resistance of 1,250 ohms, at a terminal voltage of 500. Let it be assumed that the rectifier tube is of the coated filament type through which the maximum current (R.M.S.) which may be safely passed is 0·200 ampere, and in which condition the maximum voltage consumed in the tube is 100 volts. Let it be further assumed that the source of supply is 112 volts 60 cycles.

The first quantity to be determined is the percentage ripple voltage μ.

TABLE I.

VERIFICATION OF EQUATION (6).

Load Resistance.	Smoothing Condenser.	Smoothing Inductance.	V_{dc} (measured).	V_{dc} (computed).	V_{dc} (computed, $V_0 = 0$).
Ohms.	μF	Henrys.	Volts.	Volts.	Volts.
		Half-wave Rectification, 60 *cycles.*			
3,000	4·38	0	270	307	359
5,000	4·38	0	320	365	436
3,000	8·78	0	265	282	374
5,000	8·78	0	305	329	395
		Double Wave Rectification, 60 *cycles.*			
3,000	4·38	0	345	332	415
4,000	4·38	0	375	372	416
5,000	4·38	0	383	393	424
6,000	4·38	0	395	400	454
3,000	8·78	0	345	338	389
4,000	8·78	0	378	375	409
5,000	8·78	0	370	375	400
6,000	8·78	0	380	380	430
1,000	4·38	0	262	250	322
1,500	4·38	0	318	300	376
2,000	4·38	0	340	334	415

The value of this is generally specified by the load requirements. Assume, for simplicity, a value of 13 per cent., which is a normal one. Comparison of

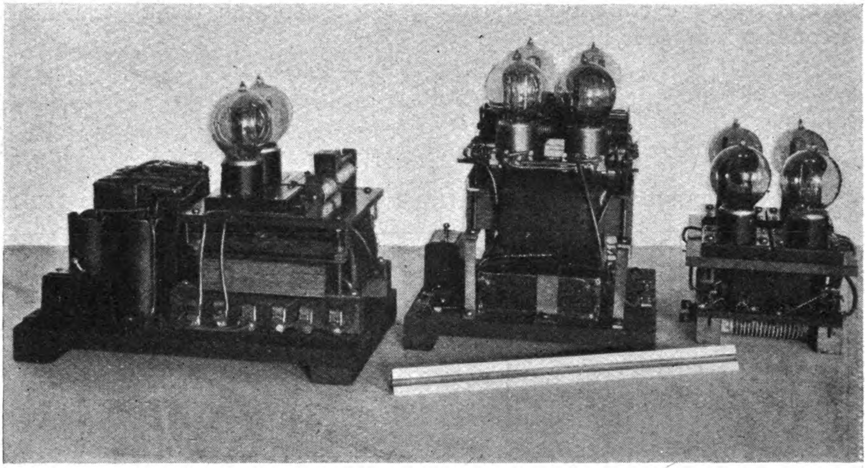

FIG. 10.

Figs. 6 and 7 shows immediately that with a load resistance of 1,250 ohms, half-wave rectification is not to be considered. Adopting double wave rectification, it is found from Fig. 7 that a smoothing capacity of 12 microfarads will give the value of μ desired.

TABLE II.

VERIFICATION OF EQUATIONS (12) AND (15).

Load Resistance.	Smoothing Condenser.	Smoothing Inductance.	μ (measured).	μ (computed).
Ohms.	μF.	Henrys.	Per cent.	Per cent.
		Half-wave Rectification, 60 *cycles.*		
4,000	4·24	0	33·3	31·3
4,000	8·96	3·30	12·6	14·0
		Double Wave Rectification, 60 *cycles.*		
4,000	4·24	0	14·5	13·3
4,000	4·24	2·20	10·0	12·5
8,000	4·24	2·20	6·5	8·3

Referring now to Fig. 9 it is observed that for a capacity of 12 microfarads and a load resistance of 1,250 ohms, the value of the voltage factor $\frac{\sqrt{2}}{1+K}$ is 0·797. By equation (9) the value of *one half* the R.M.S. transformer secondary voltage is,

$$E_{eff} = 0{\cdot}797 \times 500 - 100/\sqrt{2}$$
$$= 470 \text{ volts.}$$

TABLE III.

VERIFICATION OF RELATIONS (18) TO (21) INCLUSIVE.

Load Resistance.	Smoothing Condenser.	Smoothing Inductance.	(R.M.S. Transformer, Secondary Current) / Direct Load Current.	Rectification Efficiency.
Ohms.	μF.	Henrys.		Per cent.
		Half-wave Rectification, 60 *cycles*.		
3,000	4·38	0	1·96	56·5
4,000	4·38	0	1·97	60·5
5,000	4·38	0	2·08	61·1
6,000	4·38	0	2·14	64·1
3,000	8·78	0	1·93	59·3
4,000	8·78	0	2·00	61·1
5,000	8·78	0	2·08	66·0
6,000	8·78	0	2·09	68·0
			(Av. 2·03)	(Av. 62 per cent.)
		Double Wave Rectification, 60 *cycles*.		
2,000	4·38	0	0·900	61·0
3,000	4·38	0	0·910	71·5
4,000	4·38	0	0·937	74·0
5,000	4·38	0	0·988	77·8
6,000	4·38	0	1·010	77·2
2,000	8·78	0	0·905	66·0
3,000	8·78	0	0·915	72·1
4,000	8·78	0	0·905	73·1
5,000	8·78	0	0·908	75·2
6,000	8·78	0	0·985	72·6
			(Av. 0·93)	(Av. 72 per cent.)

The direct current through the load is equal to 500/1250 = 0·400 ampere. The R.M.S. current and power which will be delivered by the secondary transformer by empirical relations (20) and (21) will be respectively,

R.M.S. secondary current = 0·95 × 0·40 = 0·38 ampere.

Power = 200/0·70 = 286 watts.

The transformer will therefore be designed to furnish a power of 286 watts at a total secondary terminal voltage of 940 volts; the secondary winding will be designed to carry a R.M.S. current of 0·38 ampere and will have a tap brought out from the middle of the coil. The ratio of transformation will be 940/112 = 8·39.

Since it was assumed that the safe R.M.S. tube current which could be passed was 0·200 ampere, whereas the R.M.S. current which will flow under full load conditions is, by the above relation, 0·380 ampere, it will be necessary to operate two rectifier tubes in parallel in each side of the double-wave circuit, thereby reducing the current per tube to 0·190 ampere which is below the safe maximum.

Experimental Verification of the Design Relations.—The design equations and relations have been verified experimentally; verification data for the more important relations are given in Tables I., II., and III.

Comparing the values in these Tables, it is observed that there is a fair agreement between the computed and measured values of V_{dc}, when the tube voltage V_0 is taken into account. This agreement is closer with double wave than with half-wave rectification, since the former condition of operation more nearly approaches that under which the theory was deduced. With half-wave and with double wave rectification, taking V_0 into account, the maximum error does not exceed 14 per cent. and 3 per cent. respectively for the two conditions; since the rectifier tubes themselves differ 5 per cent. or more in their characteristics, it is evident that an error in computed results of 3 per cent. or even 14 per cent. is not prohibitive of sufficiently accurate design. If V_0 is neglected, an error of 30 per cent. or more may be incurred, which is needlessly large in design computations.

A view of three experimental transformer rectifier units, constructed in accordance with the preceding design relations, is shown in Fig. 10. Each of these transformers contains one high voltage and two low voltage windings, the latter for furnishing the power required for energising the filaments of the rectifier and radio-transmitting tubes. The transformer to the left and the one in the centre are for operation on 60 cycles; the high voltage power output of the former is 35 watts, and of the latter 80 watts. The transformer to the right is of the same power output as the centre one, but is constructed for operation on 500 cycles.

The three units are arranged for double wave rectification; the type VT-2 tube is employed as the rectifier.

It is desired to acknowledge the active support and interest taken in this investigation by Major-General George O. Squier, Chief Signal Officer, U.S. Army. The valuable assistance rendered throughout the experimental

work by Mr. Samuel Isler, Assistant Radio Engineer U.S. Signal Corps, is also acknowledged with pleasure.

U.S. Signal Corps, Research Laboratory,
Bureau of Standards, Washington, D.C., U.S.A.
July 7th, 1921.

The Amplification of Weak Alternating Currents.

III.—THE AMPLIFICATION AND MULTIPLE AMPLIFIERS.

By H. BARKHAUSEN.

4. The Amplification.

(a) The Efficacy of the Connections.

Corresponding to the efficiency of machinery the ratio of the amplified power P_v produced in the secondary to the unamplified power P_u supplied to the primary, should be denoted as the "amplification." In the technology of weak currents however calculations are made less often with power than with pressures and currents and therefore the root

$$W = \sqrt{P_v/P_u}$$

will be used to denote the linear amplification or simply the amplification.

If one inquires to what extent the amplification is contributed by the tube and to what extent by the external apparatus, the difficulty arises that one cannot speak of the amplification of the tube alone when, as is usual, the grid is made so strongly negative that it consumes no current and therefore also no power. The amplification would be infinitely great. As the measure of the usefulness of the tube, therefore, its figure of merit

$$G_r = \frac{4(P_a)_{\text{max.}}}{(V_g)^2_{\text{eff.}}} = S\mu$$

can serve; this is equal to four times the maximum alternating power $(P_a)_{\text{max.}}$ delivered from the tube when an alternating pressure $(V_g)_{\text{eff.}}$ of 1 volt is applied to the grid. This being given, the object of the input connections is to produce the highest possible alternating pressure V_g on the grid with a very small unamplified power P_u. Besides G_r, there is also the figure of merit of the transformer and other apparatus G_s, which in a corresponding way is put as

$$G_s = (E_g)^2_{\text{eff.}}/P_u.$$

The square of the pressure must also enter here since a fourfold expenditure of power is required for a doubled pressure. It will be remembered that the ratio of the power actually delivered to the maximum possible power on the anode side, $P_v/(P_a)_{\text{max.}}$, has been denoted as the efficiency of the anode circuit η_a, so that one obtains for the amplification,

$$W = \sqrt{\frac{P_v}{P_u}} = \tfrac{1}{2}\sqrt{G_s \,.\, G_r \,.\, \eta}.$$

When, as we have seen, the grid together with the leads associated with it possesses a definite effective impedance $\mathbf{Z_g}$, a fixed current consumption $I_g = V_g/\mathbf{Z_g}$ and consequently also a fixed power consumption P_g * is associated with the maintenance of the pressure V_g,

$$P_q = (V_g)_{\text{eff.}} (I_g)_{\text{eff.}} = \frac{(V_g)^2_{\text{eff.}}}{\mathbf{Z_g}} \approx P_u.$$

This is thus to be given by the source of current to be amplified, *i.e.*, it is essentially nothing else but the unamplified power P_u itself which is given up to the production of the pressure V_g in the grid circuit. Thence it follows that

$$G_s = (V_g)^2_{\text{eff.}}/P_u = (V_g)^2_{\text{eff.}}/P_g = \mathbf{Z_g},$$

i.e., the figure of merit of the apparatus is essentially equal to the effective impedance in ohms possessed by the grid, together with the connections associated with it, with respect to the heater. It is the impedance which, after disconnecting the source of current to be amplified, but with otherwise normal conditions for working the amplifier, can be actually measured between the grid and heater terminals, *e.g.*, by the Wheatstone bridge.

Strictly, there is a small difference between P_g and P_u with an input transformer. They will only be equal when the transformer losses with excitation on the secondary side (P_g) are just as great as with excitation on the primary side (P_u), both relative to the same secondary pressure E_g. The ratio of both will be denoted by η_g, the efficiency of the grid transformer,

$$\eta_g = \frac{P_g}{P_u}, \text{ thus } G_s = \mathbf{Z_g}\eta_g.$$

When a transformer is only essentially loaded with its own coil capacity an efficiency, in the normal meaning, cannot be spoken of; η_g is however dependent in a nearly similar way on the iron and copper losses as well as on the correct adaptation of the impedances, as is the normal efficiency of a normal transformer of the same type. An exact treatment is practically impossible on account of the distributed coil capacity.

For the linear amplification is obtained finally,

$$W = \tfrac{1}{2}\sqrt{G_s \,.\, G_r \,.\, \eta_a} = \tfrac{1}{2}\sqrt{\eta_g \,.\, \eta_a}\,\sqrt{\mathbf{Z_g}}\,\sqrt{S\mu}.$$

The magnitude of the attainable amplification is thus, apart from the correct adaptation and other losses in transformers belonging to the input and output sides ($\sqrt{\eta_g\eta_a}$), *only dependent on the figure of merit of the tube* ($G_r = S\mu$), *the effective grid impedance* $\mathbf{Z_g}$ *being made as high as possible.*

(*b*) *Magnitude Relations.*

With single-grid tubes the figure of merit of the tube $G_r = S\mu$ rarely rises above 10^{-3} watt/volt². Assuming 40 per cent. for the product $\eta_g\,\eta_a$ the value

$$W = \tfrac{1}{2}\sqrt{0{\cdot}4 \,.\, 10^{-3}\,\mathbf{Z_g}} = \sqrt{\mathbf{Z_g}/10{,}000} \quad (\mathbf{Z_g} \text{ in ohms})$$

* The simplification is due to neglecting the phase-displacement, the power thus being put equal to the volt-amperes.

is obtained for the amplification. The effective grid impedance must thus exceed 10,000 ohms before any amplification is obtained at all. With $Z_g = 100{,}000$ only 3·2-fold, with 1 megohm 10-fold and with 10 megohms 32-fold amplification is obtained.

With double-grid tubes the figure of merit of the tube is about 10 times as great. Thus one obtains the same amplification with $\frac{1}{10}$ the value of Z_g, or with the same Z_g 8·2 times greater amplifications.

In note amplifiers the effective coil-capacity of the input transformer, as previously mentioned, amounts to about 80 cm. Without resonance this gives an effective grid impedance $Z_g = 1/\omega C = 2$ megohms. By resonance with the coil inductance Z_g is increased to about 10 megohms, but only over a narrow range of frequency.* With single-grid tubes this gives a 14 to 32-fold amplification; which is in fact the magnitude which is obtained with good amplifiers.

Transformers for low frequencies have about the same capacity; that of the measuring transformer described by Gewecke (*loc. cit.*) was about 80 cm. At 50 cycles per second this corresponds to a 20-fold greater impedance $1/\omega C = 40$ megohms. Gewecke found that at resonance with 1 volt on the primary a current of only 0·05 milliampere was required to produce 70 volts on the secondary. This gives for the figure of merit of the device

$$G_s = (E_g^2)_{\text{eff.}}/P_u = 70^2/1 \times 0{\cdot}05 \times 10^{-3} = 10^8 \text{ ohms.}$$

Including the transformer loss a primary power of only 10^{-8} watts was necessary to maintain a pressure of 1 volt on the secondary. With this transformer and a single-grid tube a 100-fold amplification would thus be possible, but only with very good insulation. Except for the high number of turns which the transformers must have (**Gewecke's** had 150,000) low frequency amplifiers offer few difficulties.

On the other hand still greater difficulties arise with increasing frequencies. Though the coil capacity be reduced to a few centimetres by proper winding the effective grid capacity will however hardly be less than 10 cm in consequence of the unavoidable connecting leads. This gives :—

λ metres = 20,000 .	10,000	2,000	1,000	600	300	100
$1/\omega C$ ohms = 10^6 .	500,000	100,000	50,000	30,000	15,000	5,000

Below a wavelength of 600 metres no amplification at all is produced by single-grid tubes without resonance tuning. Resonance can easily be made pretty sharp with high frequencies; $d = 0{\cdot}1$ is easily obtained. The effective grid impedance will be made thereby $\frac{\pi}{d} = 31{\cdot}4$ times as great and the amplification thus nearly 6 times higher. A difficulty is moreover still found, since with such sharp resonance only quite a narrow range of fre-

* From the considerations of **Schottky** in the *Archiv. für Elektrotechnik*, 8, p. 6, it follows that a figure of merit of the connections $G_s = 4 \times 10^6$ ohms may be regarded as normal.

quency will be well amplified, so that retuning is continually necessary, which is not desirable. It is also not easy to carry out, since the means of tuning should not appreciably increase the capacity of 10 cm.

Since the capacity of the anode to earth (to the filament) can also hardly be reduced to less than 10 cm the difficulty arises, as the above table shows, with short waves and large R_i in the tube (100,000 ohms) of making the external impedance $\mathbf{Z}_a$ in the anode circuit sufficiently big. One must here definitely work with resonance, or better employ tubes with space-charge grids and smaller voltage ratio for which R_i is small. It is to be noticed with respect to the action of C_{ga}, the capacity between grid and anode which was considered above, $\mathbf{Z}_a$ is preferably made about 4 times smaller than R_i. According to Table I. this is still no unfavourable adaptation and reduces the effective grid capacity from μ times to $\mu/5$ times C_{ga}. Tubes with large μ are disadvantageous, since with them the amount of grid capacity arising from C_{ga} will be very large. The inclination to self-excitation is proportionately great. To suppress this, inductive coils must be inserted in the anode circuit with very many turns which will let through little current. $\mathbf{Z}_a$ then remains already capacitive through the capacity of the connecting leads, since these let through a capacity current, and self-excitation due to C_{ga} cannot occur.

(*c*) *Back Coupling.*

It has already been mentioned that the figure of merit of the device can be enhanced to any desired extent by means of back coupling, a reaction of the amplified on the unamplified current which reduces as much as desired the power P_u necessary for the production of a specified power P_v. The back coupling acts as a negative resistance which annuls the damping effect of an equally great positive resistance. By means of an adjustable back coupling the total damping can therefore easily be brought to zero. The effective grid impedance $\mathbf{Z}_g$ will then be infinitely great at resonance and, theoretically, an infinitely great amplification can be produced. It should be noticed, however, that the neutralisation of the damping resistance R can only produce the desired effect so long as $\omega L - 1/\omega C$ is correspondingly reduced, and the resonance is sufficiently perfect. Now by means of the back coupling the effective inductance and capacity will also be altered, in general. Besides the variable back coupling one must therefore still employ effective means of fine tuning, so that resonance with the currents to be amplified is maintained. The optimum will only be obtained when both adjustments are simultaneously correctly made, which necessitates no small skill in operation.

The difficulty of adjustment is increased by the fact that with a small over-shooting of the most favourable back coupling the total damping becomes negative and self-excitation sets in ; the normal amplifying action being thus destroyed. Self-excitation once produced often remains long continued. The back coupling must then be largely reduced so that it ceases. If the back coupling be then carried forward again in order to adjust the optimum one runs into danger of starting self-excitation again with

some strong impulse; it is then continuous. Since small external impulses are always present the optimum cannot be at all accurately adjusted.

Notwithstanding these difficulties one succeeds in producing in this way with high frequencies surprisingly high amplifications from one single-grid tube, but only with very skilful adjustment. Such apparatus—audion receivers with back coupling—though not quite so simple to employ are much in use. The reason lies partly in this, that, as mentioned, it is so difficult—and for short waves nearly impossible—to produce normal high frequency amplifiers capable without special tuning of covering a wide range of wavelengths.

With low, audible and long wave frequencies, on the other hand, even with quite flat resonance one can still keep the grid impedance $\boldsymbol{Z_g}$ easily over 1 megohm and thus produce more than 10-fold amplification over a wide range of frequency without any adjustment. Higher amplifications can then be obtained without difficulty with multiple amplifiers. (See the following section.) With audible frequencies it is usual to employ no back coupling but, on the contrary, carefully to avoid it, since it favours certain frequencies and easily leads to self-excitation. Alterations in the insulation, changing a tube (particularly with not quite good vacuum), alteration of the capacity by movement of the connecting leads or neighbouring conductors, alters also the effective back coupling; once self-excitation sets in one is, without adjusting apparatus, quite powerless. With stronger reduction of damping due to back coupling the long echoes—which will be excited with low and audible frequencies shortly before self-excitation, not only by the signals but also by each amplified current impulse—will be very troublesome.

5. Multiple Amplifiers.

(*a*) *Limits of Amplification.*

Although a certain amplification is obtainable in general with one tube there is a much better means of securing higher amplifications, namely: to lead the current amplified in one tube into a second, thence after amplification to a third and so on. If one tube amplifies 10-fold, an amplification of 100 with two tubes and of 1,000 with three tubes is obtained,* so that nearly unlimited amplification can be secured.†

A practical limit will be reached, on the one hand, since the disturbances (proceeding in part from the tube itself) also become amplified, so that finally with a higher amplification weak signals are not improved but actually made worse; and on the other hand since it will still be difficult to suppress back coupling and the self-excitation to which it leads.‡ Self-excitation

* In experiments on earth current telephony by the firm of **Siemens and Halske** a larger amplifier was connected after a four-tube amplifier which amplified 10,000-fold; by means of this, signals only audible in the telephone after the 10,000 times amplification were made quite audible over the whole room. This corresponds at least to a further 100-fold amplification, altogether 10^6-fold linear or a 10^{12} power amplification being obtained. On account of the augmented disturbances reception was clearer and better without the second amplifier.

† A theoretical limit is according to **Schottky** (*Verhandlungen der deutsche Physikalischen Gesellschaft*, 20, p. 71, 1918) given by this, that finally the separate electrons flying across become audible.

‡ Details will be published later.

can already occur very easily in a tube when the back-coupling impedance is equal to the effective grid impedance; thus when, *e.g.*, the back-coupling capacity is about equal to 50 cm, as mentioned above in connection with audible frequencies. If the pressure is amplified 1,000-fold perhaps by means of three tubes, a capacity about 1,000 times as small will suffice, *i.e.*, about $\frac{1}{2}$ mm or about that of a sphere 1 mm diameter. Thus then a lead of about the size of a pin's head associated with the grid of the first tube can give rise to self-excitation when it is not electrostatically screened from the amplified pressure. Such protection will be most effectively obtained by enclosure within a conducting screen which can receive no alternating potential, *e.g.*, is earthed. With high amplifications, therefore, not only are the triodes and the transformers surrounded by well earthed metallic casings (shown dotted in Fig. 15), but also the leads from the transformer to

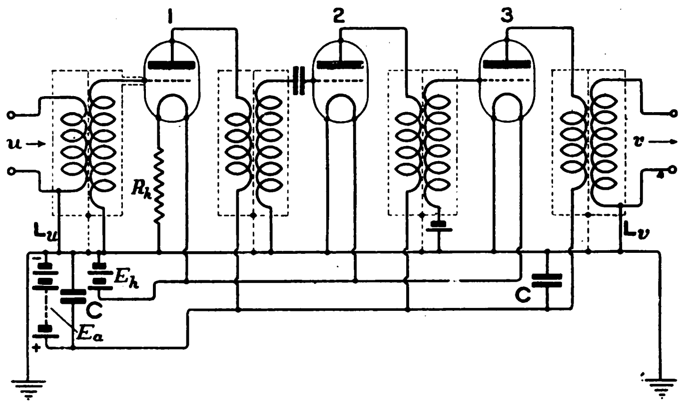

FIG. 15.

the triode are taken through an earthed lead tube. (See Fig. 15, first tube.) The effective grid capacity will certainly be increased thereby and the figure of merit of the apparatus somewhat impaired, but the inclination to self-excitation will be enormously reduced. In spite of such protection self-excitation often still occurs in consequence of the capacity between the outgoing (v) and the incoming (u) leads. Since these and the apparatus connected to them cannot be sufficiently protected against one another, it is then well to make the connecting apparatus of the lowest possible ohmic resistance and to earth one pole. (See Fig. 15, leads L_u L_v.) High potential differences can then nowhere be induced between them. Inductive influences, in consequence of stronger currents with apparatus of low ohmic resistance, are not so dangerous and can easily be made harmless.* An earthed metallic screen between the primary and the secondary windings

* The following fact shows this: Often input and output transformers have tappings for the adaptation of various external apparatus resistances. It is then nearly always found that self-excitation occurs much more easily with the high resistance sections.

of the input and output transformers will also be a good thing. (See Fig. 15.) Such thorough-going protective measures are only necessary with very high amplifications, say over 1,000-fold.

(b) Practical Performance.

Common heating and anode batteries can be employed for all the tubes (Figs. 15 and 16, E_h and E). The internal resistances of these must be so small that they can act as a short-circuit to the alternating current. Otherwise the resulting alternating pressure forms a back coupling which easily leads to self-excitation. According to the amplification, perhaps 100 to 10 ohms is still permissible. With audible frequency a sufficient short-circuit is produced, if necessary, by means of a condenser in parallel with E_a (C, C in Fig. 15). With high frequency the inductive pressure drop in the common connecting leads forms a considerable back coupling.

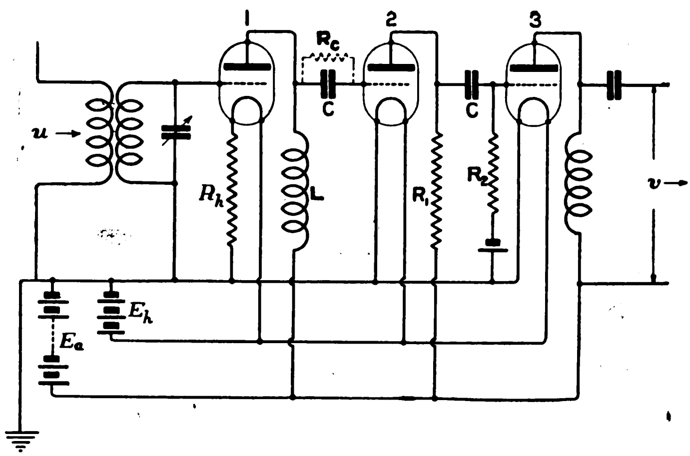

FIG. 16.

Fig. 15 shows the connections of a 3-fold amplifier with intermediate transformers. These lead the current amplified in one tube to the grid of the following tube and must thus adapt the internal resistance R_i of a tube to the effective grid impedance of the next tube, Z_g. As mentioned above, these grid transformers work most suitably by coil-resonance. If, as with tubes with a large voltage ratio or with a second protective grid, the internal resistance R_i is very great, or, as with high frequencies, the effective grid impedance Z_g is pretty small, then very nearly $R_i = Z_g$. A transformer between two tubes then gives no further advantage. Fig. 16 shows such a scheme of connections without transformers. The anode direct current flows through a choking coil (L in Fig. 16 for the first tube) or an ohmic resistance (R_1 for the second tube). In the latter case the ohmic pressure drop is generally balanced out by a corresponding increase in the anode battery E_a. The choking coil works most suitably with coil resonance since it then

possesses the greatest impedance. It is, then, dimensioned exactly as the secondary winding of the intermediate transformers. The alternating pressure will be led to the grid of the following tube through a small condenser C (about 200 cm) which must be large compared with the capacity of the tube. The grid pressure V_g is then equal to the anode pressure V_a of the foregoing tube. The amplification of a tube is the ratio of the pressure on its two sides, *i.e.*,

$$V_g/V_a = W = \frac{\mu}{1 + R_i/Z_a} = \frac{1}{\frac{1}{\mu} + \frac{1}{SZ_a}}.$$

It is to be understood that the total impedance between the connecting leads anode-grid and earth (filament) is included in Z_a. Therefore, Z_a is identical with the Z_g of the next tube. So long as Z_g remains great compared with $R_i = \mu/S$ then $W = \mu$. For $\frac{1}{\mu} = 7$ per cent., for example, a 14-fold amplification is obtained. Tubes with a large voltage ratio μ, in particular double-grid tubes with protective grids, are peculiarly suited to this method of connection. An increase of μ is no more advantage so soon as $R_i = \mu/S$ becomes great compared with Z_a, which certainly soon occurs with high frequencies. Double-grid tubes with space-charge grids—in which S is large—are then more favourable. Quite generally, the amplification will be a maximum with a given figure of merit of the tube $G_r = S\mu$ when $\mu = SZ_a$, thus again when $R_i = Z_a$.

The small negative applied pressure, which the grid must have can be produced by means of a resistance R_h (shown in Figs. 15 and 16 with the first tube) in the negative filament current lead, since the negative end of the filament will then be positive to the grid by the potential drop I_hR_h. This certainly means a waste of energy and a correspondingly higher filament battery P.D., but, notwithstanding, this is a most usual method of connection since it easily allows of any desired potential by suitable choice of R_h. A condenser can also be put in the lead to the grid (shown in Figs. 15 and 16 with the second tube).* As previously mentioned the isolated grid then becomes slightly negatively charged, but only if the tube has a very good vacuum and very good insulation. With the connections shown in Fig. 16 the condenser C must be excellently insulated (*i.e.*, large R_c, shown dotted) to protect the grid from the high anode potential. This is certainly only necessary when the impedance $Z_a \doteqdot Z_g$ can otherwise be maintained high. If this is not at all possible—as with high frequency on account of the capacitive shunting—the electron current I_g to the grid in the tube will not become perfectly zero. The theory shows that in tubes with a good vacuum such a current acts as a leak of resistance,

$$R_g = 1/4I_g \text{ ohm } (I_g \text{ in amperes}).$$

* In an American amplifier the middle of the secondary winding of the grid transformer was simply broken. The capacity between the neighbouring halves of the winding replaced the condenser.

R_g may become, *e.g.*, 100,000 ohms because Z_g is essentially smaller, and thus I_g may become 1/400,000 ampere. With an anode pressure of 100 volts in this case the insulation resistance is $R_c = 100 \ . \ 400{,}000 = 40$ megohms.* Often an effective resistance of this very magnitude is connected in parallel with the condenser, independently of the otherwise quite indeterminate condition of the insulation; but particularly because otherwise a strong negative charge on the grid excited by an excess pressure with higher insulation can only leak away quite slowly; the tube during this time being inoperative.

A third possibility which will produce the negative applied pressure on the grid is the connection of a separate auxiliary pressure thereto (*e.g.*, quite a small dry cell, as shown with the third tube in Figs. 15 and 16). With the transformerless connections shown in Fig. 16 this is put in series with a resistance R_2 (or a choking coil) which must be large compared with Z_g. The pressure drop in this can then appreciably displace the grid potential.

(*c*) *Particular Properties.*

On account of the resonance properties of the secondary windings the connection using transformers (Fig. 15) amplifies for audible frequencies a range of only about 1 to 2 octaves (1:2 to 1:4), and also within this range more or less markedly prefers certain frequencies according to the sharpness of resonance of Z_a and the ratio of Z_a to R_i (see the discussion of Figs. 4 and 5). This is generally a disadvantage, especially for the amplification of telephonic currents. This can be partially adjusted by tuning the transformers to various frequencies, any transformer being preferably tuned still lower than that preceding it, in order to prevent the back coupling and consequent danger of self-excitation due to the capacity C_{ga} (see Section **3** (*c*)). The varied tunings can be obtained by different arrangements of the windings of similar transformers. The whistling of an amplifier can often be entirely removed merely by changing the polarity of a transformer. By this changing of polarity all other back couplings—so far as they go through the transformer, *i.e.*, between the leads before and behind a transformer—become converted from positive, reducing the damping, to negative, increasing the damping or the reverse; and with simultaneous alterations of the natural frequency. This must be particularly attended to with high amplifications, since a capacitive back coupling between the unprotected, unearthed leads u and v to the apparatus turns out negative. For frequencies above and below resonance the currents have nearly 180° phase displacement; therefore, though by changing the polarity of a winding one sustained whistling sound can be suppressed, another may be set up with a different natural frequency. In order radically to destroy the resonance properties of the transformers the secondary can be loaded with a resistance of about 1 megohm (see Fig. 13). This is done most simply by giving to the grid too small a negative potential, so that the electron current to the grid I_g will not be

* If as is the case with audible frequencies, Z_g is equal to or greater than 1 megohm R_g must be 10 megohms and R_c over 4,000 megohms. Here therefore insulation questions play a much greater part than with the connections using transformers.

quite zero. By small alterations of the pressure an effective loading resistance R_g of any size can be secured.* As mentioned, with 1 megohm and a normal single grid tube an amplification of 10 is still obtained equally over a wide frequency range ; self-excitation is then hardly to be feared. Amplifiers are often found in which an increase in the negative grid potential causes self-excitation, so that this means of suppression has thus already been made use of more or less unwittingly.

The method of connection without intermediate transformers, but with the choking coil L (Fig. 16) in the anode circuit, is strictly only a variety of that with transformers. The choking coil can be thought of as an auto-transformer with a transformation ratio of unity. High amplifications are also only obtained here with large impedances $Z_g \doteqdot Z_a$, and then on account of the coil capacity exactly the same resonance phenomena occur as with the transformer. All that has been said above is also valid here. Theoretically, the transformer connection still gives a little higher value since it renders possible a perfect adaptation of impedances $\tau^2 R_i = Z_a$. Only when $R_i = Z_a$ will both arrangements be equivalent. In this the coil capacity of the primary winding is neglected ; with high frequencies this can be rejected and the transformer is then thought of as a coupling between two oscillatory circuits. The most favourable relations are present with resonance when both coils have equal natural oscillations, *i.e.*, essentially equal numbers of turns. Then, since the transformation ratio is 1:1, the choking coil is theoretically equivalent to the transformer and simpler in practice. Thus, while the transformer connection is somewhat more favourable for audible frequencies, preference will be given to the transformerless connection for high frequencies. The greater insulation difficulties belonging to this method—see above—are not of such importance with high frequencies, since all the effective impedances arising from the unavoidable capacitive shunts are so much smaller.

The use of a resistance (R_1 in Fig. 16) in the anode circuit in place of the choking coil L has the advantage that the amplifier does not obtain any resonance properties therefrom ; thus the lowest frequencies (telegraphic signals) are just as well amplified as the highest, up to the limit where the capacitive shunts and the back coupling due to them become effective. Self-excitation can also occur here, particularly with quite short wavelengths where the inductance of the connecting leads already plays a part. Here again high amplifications imply high resistances ; 1 megohm is, as mentioned, necessary for a 10-fold amplification. On account of the direct current pressure drop this introduces difficulties. The slope of the characteristic is not very considerable with less than about 0·2 milliampere ; the anode direct current must therefore be about this value. Hence one megohm implies a pressure drop of 200 volts with 0·2 milliampere, and the anode battery must be increased by this amount as compared with that required with a connection using practically resistanceless choking coils. If the

* According to the rule mentioned in the former section R_g is 1 megohm for $I_g = 2{\cdot}5 \times 10^{-7}$ amp. Such a small current thus forms a considerable load.

internal impedance Z_u of the source of current to be amplified is not extraordinarily great an input transformer is used, which again brings resonance properties with it. The difficulty of amplifying telegraphic signals depends chiefly on this since an input transformer for frequencies of about 1 per second will assume large dimensions and have a huge number of turns. Without a transformer and with an internal impedance Z_u of the leads of 1,000 ohms there is obtained with a grid impedance of only 1 megohm—according to Table I.—a 15·8-fold smaller amplification than for the case of the most favourable adaptation. At least one tube more is used to obtain the same amplification ; the more so as on the output side the most favourable adaptation will seldom be obtained.

Summary.

(1) The power delivered on the anode side is greatest when the resistance of the load apparatus is equal to the internal resistance of the tube, R_i. Practically they need only be of the same order of magnitude. Deviations from the optimum condition in the ratio of 1:4 or of 4:1 only produce a just perceptible weakening (25 per cent. linear).

(2) If the resistance of the apparatus is not in itself high an increase in its effective resistance can be obtained by means of an intermediate transformer, or, with inductive apparatus, by connecting a condenser tuned to resonance in parallel with it ; or by both means.

(3) The power supply on the grid side is dependent upon the magnitude of the " effective grid resistance." With sufficient negative potential this is only limited by capacity or insulation.

(4) The higher the effective grid resistance the greater is the influence of disturbances due on the one hand to stray potentials and on the other to the amplified currents themselves. The latter lead to self-excitation and whistling.

(5) The input transformer must adapt the internal resistance of the source of current to be amplified to the high grid resistance. The number of its secondary turns is limited by the coil-capacity which acts as a condenser in parallel with the grid, thereby reducing the effective grid resistance. It is best to work with resonance. (See (2).)

(6) The capacity between the grid and anode, lying partly in the tube and partly in the connecting leads, represents a back coupling which cannot be neglected. According to the magnitude and phase of the impedances lying in the anode circuit it can, on the one hand, act as a considerable grid capacity which diminishes the grid impedance ; or, on the other hand, as a negative leak which diminishes the damping and finally causes self-excitation. This self-excitation cannot occur when the impedance of the anode circuit is capacitive when, for example, it is tuned to a lower frequency than the effective grid impedance.

(7) The amplification (apart from the efficiency of the output transformer) is equal to half the geometric mean of the figure of merit of the tube and the figure of merit of the connections.

(8) The figure of merit of the connections (apart from the efficiency of the input transformer) is identical with the effective grid impedance.

(9) An effective grid impedance of 1 megohm gives a 10-fold amplification with single-grid tubes and about 32-fold with double-grid tubes. With low and audible frequencies the grid resistance can rise to about 10 megohms; this corresponds to a 3·2 times higher amplification. On account of the low capacitive impedance with high frequencies, and particularly with short waves, it is difficult to obtain any amplification at all. Double-grid tubes are here most favourable.

(10) By means of an adjustable back coupling and simultaneously sharp resonance tuning, the effective grid resistance, and therewith the amplification can be carried very high. However, expert operation is necessary so that this means will only be employed with high frequency where difficulties are otherwise encountered.

(11) With low and audible frequencies, and with long waves, any desired amplification is obtained simply by connecting normal amplifiers one behind the other. This allows of the construction of apparatus which is handy and requires no attention.

(12) A limit to the amplification is then given by the amplified disturbances, which finally make higher amplifications worthless. Also with very high amplification—over 1,000-fold—self-excitation can only be suppressed with difficulty.

The Report of the Wireless Telegraphy Commission.

The publication of the Report of the Commission appointed by the Cabinet on December 23rd, 1920, marks an epoch in the development of radio-telegraphy. The terms of reference were (i.) To decide upon the wireless plant most suitable for carrying out the scheme of Imperial Wireless Communications recommended by the Imperial Wireless Telegraphy Committee, bearing in mind the necessity for the co-ordination of the chain with existing telegraph services and to design the necessary stations. (ii.) To make recommendations regarding the actual sites for the stations. (iii.) To advise generally upon the preparation of specifications for machinery and apparatus, the making of contracts and the construction of the stations.

The Report is signed by Dr. Eccles, Mr. L. B. Turner and Mr. E. H. Shaughnessy and is prefaced by an explanatory summary by Dr. Eccles.

The hands of the Commission were tied in so far as they were bound by the recommendations of the Committee (1) to communication by steps of about 2,000 miles, (2) to adopt thermionic valves as generators, and (3) to certain locations for the stations. In view of the fact, however, that the Commission consisted almost entirely of the technical members of the Committee, they were in reality only carrying out their own recommendations.

The first technical section of the Report deals with the development of high-power thermionic sets. As is well known, since the Committee recommended the adoption of thermionic transmitters for the Imperial chain,

great progress has been made in the equipment of such transmitting stations by the Marconi Company and the Commission report on their visit to Carnarvon to examine the set of forty-eight glass valves with an input of 100 kilowatts which was pushed up to 150 during the trial. Messages were successfully transmitted to America, India and Australia. The relative merits of glass and silica valves are discussed; it is stated that $2\frac{1}{2}$ kilowatt silica valves are being produced at the rate of four or five per week at a cost of about £60 each, whereas the glass valves, of which about four times as many would be required, can be produced in ample numbers at a cost of about £15. Hence there appears little to choose between them at present as regards cost, but the manufacture of glass valves is undoubtedly simpler and more standardised at present. It is stated that valve renewals will be from 50 to 66 per cent. heavier if alternating current is used instead of direct current, presumably due to the use of thermionic rectifiers.

With regard to wavelength it has been found as the result of tests between Horsea and Egypt that the best results over this distance can be obtained by the use of a relatively short wave during the night and of a long wave during the day time. The aerial tuning coil is therefore to have tappings so that the wavelength can be varied from 3,000 to 16,000 metres. It is to be designed to carry 500 amperes and its high-frequency resistance must not exceed a third of an ohm. In view of our present knowledge everyone will agree with the recommendation to adopt a symmetrical form of antenna supported by four masts at the corners of a square not exceeding 400 metres side, with the station and down lead at the centre. The capacity of the aerial is to be about 0·025 microfarad. Although no one doubts the superiority of the high over the low antenna, many readers will await with interest further details of "the deeper study of the better wave-making properties of high as compared with low antennæ."

It is recommended that the masts be of steel, 250 metres high, insulated not only at the base but at intermediate points, the insulating [insulated ?] portions being suitably dimensioned presumably with a view to a better distribution of potential and consequent diminution of losses.

In view of the recent experiences at Clifden and Carnarvon it is not surprising to find that earth screens or counterpoises, not less than 8 feet above the ground are recommended.

The Commission appear to have considered or tried a large number of panaceas for atmospheric interference but to be enamoured of none of them. Finding some benefit in the Horsea-Egypt trials from each of three different devices, viz., balancing, limiting and barraging, they recommend that all three be applied simultaneously.

With regard to duplex working it is recommended that each receiving station should have a separate antenna and receiving apparatus for each distant station with which it may have to communicate, so as to allow of simultaneous reception from all.

The transmitting set is to be capable of delivering at least 120 kilowatts to the antenna and is to be capable of extension to double this power. The D.C. supply is to be at 10,000—12,000 volts, the method of its production

being left open. The set is to be capable of transmitting continuously either at hand speed or at ninety words per minute at full power.

It is noteworthy that although the Commission recommend that arc transmitters (two each of 250 kilowatts) be installed at East Africa, Singapore and Hong Kong, they also recommend that space be provided in every case for the subsequent installation of thermionic plant. They also recommend that the arc station recently installed in Egypt should be duplicated by a thermionic valve station. Nowhere in the Report is the slightest reference made to the radio-frequency alternator, whilst the arc is obviously regarded as a temporary expedient.

The Committee had recommended that the old German station at Windhuk should be modified to form the South African Chain Station, but the Commission report that the Union authorities favour the erection of a new station near Johannesburg on account of the long and costly land lines which the adaptation of the Windhuk station would entail.

The attitude of Canada with regard to the scheme seems to be in some doubt and the Commission recommend a conference with the Canadian authorities.

The cost of the five stations for which the Imperial Government is presumed to be responsible is estimated not to exceed £853,000; these stations are England, Egypt, East Africa, Singapore and Hong Kong, the three last being those stations for which arc generators are recommended for the present.

Perhaps one of the most striking things in the Report is the suggestion that the Marconi Company should be invited to tender for the valve set, tuning coil and earth screen for the British station. It is not quite clear, however, whether it is intended that only the one company should be invited to tender, to the exclusion of other firms, but the wording of the Report would certainly lead one to conclude that this is intended.

The Report concludes with a number of plans with leading dimensions of the ground required for the various stations, and of the power houses, transmitting and receiving buildings.

G. W. O. H.

Review of Radio Literature.

1. Abstracts of Articles and Patents.

(A.) Radio Stations and Installations.

3015. Wireless Telegraphy in the French Colonies. (*Radioélectricité*, 1, pp. 129—140, August; pp. 189—197, September; and pp. 248—255, October, 1920. *Génie Civil*, 78, p. 119, January 29th, 1921.)

3016. **L. M. Clement, F. M. Ryan** and **De Loss K. Martin.** The Avalon-Los Angeles Radio Toll Circuit. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 469—505, December, 1921.)

Describes in great detail the radiotelephone link which enables subscribers of the Bell Telephone System to call any subscriber at Avalon on Santa Catalina Island (off southern California). The system used is duplex using two different carrier frequencies (wavelengths 400 and 470 metres) and is connected through special two-way repeaters to the telephone systems both on the island and on the mainland.

Loop antennæ are used at both radio stations for reception. These are of the solenoid type, 6 feet square and consist of four or five turns each. Filter circuits are used to prevent the transmitting frequencies from entering the receiver. The transmitters are of the "constant current" type (anode choke control).

Various special points of the system are discussed, among them being an automatic alarm system which indicates when the transmitter ceases to oscillate for any reason.

(B.) Spark Transmitting Apparatus.

3017. **G. B. Crouse** [Sperry Gyroscope Company]. Spark Gap. (*U.S. Patent* 1399005, June 14th, 1918. Patent granted December 6th, 1921.)

This invention relates to a spark-gap construction for a buzzer transmitter, operated from a direct-current source. The spark-gap construction comprises a vibratory electrode, a portion thereof being magnetic material whereby the electrode may be vibrated by energising an adjacent electromagnet. A plurality of insulated electrodes are arranged to be normally bridged across the vibratory electrode.

(C.) Arc Apparatus.

3018. **P. O. Pederson.** Some Improvements in the Poulsen Arc, Part I. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 434—441, October, 1921.)

A Poulsen arc may be run with either one or two peaks of the arc voltage during one cycle. One-peak operation is the ideal method since it gives a radio frequency current wave of almost perfectly pure sinusoidal shape. This type of operation, though rather unstable in ordinary sets, has been satisfactorily attained by the use of a water-cooled copper shoe on the cathode which prevents the arc from travelling along the cathode. Other advantages of the use of this cooling shoe are that it permits the use of weaker magnetic fields and also that a great increase in the steadiness of the arc is found to accompany its use.

(F.) Thermionic Valves and Valve Apparatus.

3019. **T. Johnson, Jun.** Naval Radio Tube Transmitters. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 381—433, October, 1921.)

Deals exhaustively with the development of valve transmitters in the Navy Department of America. The superiority of tube transmitters over spark and arc sets has been shown by a long series of tests carried out at Washington in 1919. Signals from sets of the three types mentioned were sent out on a wavelength of 1,900 metres the antenna current in each case being 8 amperes. In order to permit a simple review of the results the audibilities obtained at the eleven receiving stations have been turned unto factors giving comparative

audibilities, the actual audibility of spark signals received by detection only being assumed as unity. The average results are tabulated below.

TRANSMITTER.	RECEIVER.	AVERAGE AUDIBILITY.
Spark.	Detection only.	1
Spark.	Detection and Regeneration.	3·5
Continuous wave modulated.	Detection only.	12
Spark.	Oscillating.	24
Arc.	Oscillating.	105
Valve.	Oscillating.	205

The standard transmitters are described in detail. The circuits in use are either (*a*) those in which the plate and grid circuits are inductively coupled to the antenna circuit or (*b*) examples of Colpitt's circuit in which the grid receives its excitation from a condenser in the antenna circuit.

A careful investigation of the antenna characteristics is made in the case of stations to be equipped with valve transmitters a special test set having been developed for the purpose by the author and manufactured in quantity by the General Electric Company.

The article is copiously illustrated with photographs showing constructional details of the 5-, 150-, 300-, and 750—1,500-watt equipments.

3020. **J. H. Payne, Jun.** [General Electric Company]. Method of and Means for producing Alternating Currents. (*U.S. Patent* 1400235, September 14th, 1916. Patent granted December 13th, 1921.)

This patent shows a vacuum tube circuit for the production of alternating currents. The coupling between the grid and the plate circuits is provided by condensers. The main inductances and the capacities are preferably so chosen that radiofrequency oscillations will be set up in the circuit which includes these inductances and capacities. Other inductances and condensers are so proportioned that the circuit including these inductances and capacities will be resonant to a different and preferably an audible frequency.

(G.) Transmitter Control or Modulation.

3021. **H. F. Elliott, assignor to Augustus Taylor.** Radiotelegraphy. (*U.S. Patent* 1399945, July 24th, 1920. Patent granted December 13th, 1921.)

This patent relates to a high-power arc signalling system in which the signals are produced by a variation in wavelength of the radiated wave. The antenna inductance is changed to produce the signals by the closing of a plurality of pairs of contacts in a system of loops inductively associated with the antenna inductance.

3022. **C. D. Ehret.** Electrical Wave Transmission. (*U.S. Patent* 1400591, March 12th, 1919. Patent granted December 20th, 1921.)

This invention relates to the transmission of radiotelephone signals wherein high-frequency oscillations are not existent or produced except when the microphone is actuated. The oscillator employed in the system includes a pair of anode circuits, a heated cathode and a grid circuit. An amplifier may be inserted between the microphone circuit and the oscillator and between the oscillator and the antenna radiating system. In the operation of the system modulating energy is impressed by a transformer upon the anode circuits of the oscillator with the result that all of the frequencies of positive polarity are converted by one of the anode circuits while all of the frequencies of negative polarity are converted by the other of the anode circuits. Thus, there are directly produced, by conversion of the amplified telephonic energy, high-frequency oscillations varying in amplitude in accordance with speech waves. The telephonic energy is the only energy supplied to the plate or anode circuits as distinguished from systems wherein a battery supplies the anode circuit and wherein only the telephonic energy is employed merely to vary the potential of the grid of the oscillator.

(H.) Radio Receiving Apparatus.

(4) HETERODYNE AND C.W. RECEIVERS.

3023. **V. Bush** [American Radio and Research Corporation]. Radio Receiving System. (*U.S. Patent* 1389026, May 19th, 1920. Patent granted August 30th, 1921.)

Radio receiving system for the reception of sustained oscillations which are broken up or

modulated into groups at an audible frequency by periodically varying the resistance of the receiving circuit at audible frequency. (See Fig. 1.)

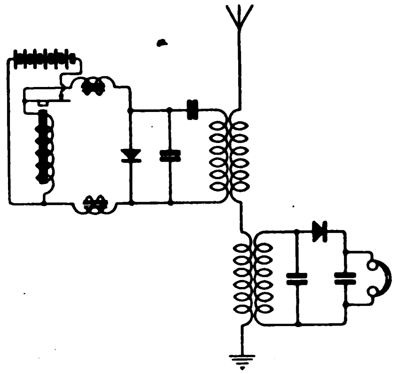

FIG. 1.

(5) RELAYS, RECORDERS AND AUTOMATIC CALLING APPARATUS.

3024. **H. J. J. M. de R. de Bellescize.** Type Printing. (*French Patent* 508833, January 22nd, 1920. Published October 25th, 1920.)

The specification describes wireless type-printing telegraph apparatus which consists in modifications of the Baudot system. See also *British Patent* 158556, and RADIO REVIEW Abstract No. 3013, February, 1922.

3025. **L. B. Turner.** Wireless Receiving Apparatus. (*British Patent* 152915, February 13th, 1920. Patent accepted October 28th, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 222—223, September, 1921—Abstract.

For high-speed reception the slow dying away of the oscillations sets a limit to the working speed. A relay is used (operated by the signal) so that as soon as the signal is received an additional damping means is inserted in the circuit to promote the rapid quenching of the oscillations.

3026. **Siemens and Halske Akt. Gesellschaft.** Thermionic Relays. (*British Patent* 146354 July 2nd, 1920. Convention date May 27th, 1919. Patent not yet accepted.)

An arrangement of thermionic valves for high speed reception, as indicated in Fig. 2. The current through the relay R is reversed on the receipt of a signal.

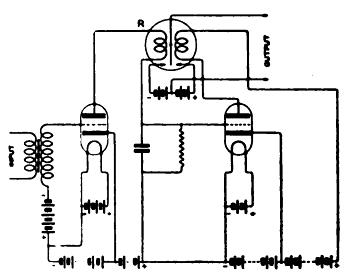

FIG. 2.

3027. **F. A. Johnsen** and **K. Rahbek.** Relays. (*British Patent* 151997, October 4th, 1920. Convention date February 15th, 1919. Patent not yet accepted.)

3028. **M. Compare** [Comparri Wireless Control Syndicate]. Wireless Type-printing Telegraphy. (*British Patent* 150008, March 7th, 1919. Patent accepted September 2nd, 1920.)

Each letter is represented by a combination of two or more trains of impulses of different group frequency transmitted in quick succession and received by resonance relays.

3029. **A. H. Brantom, E. A. Bitton, A. W. Dransfeld** and **S. E. Boyce.** Relays. (*British Patent* 152153, July 24th, 1919. Patent accepted October 14th, 1920.)

A tuned contact-making relay, consisting of a plurality of adjacent diaphragms influenced by a single electromagnet. The arrangement is applicable to reducing interference in wireless reception.

3030. **C. A. Hoxie.** A Visual and Photographic Device for Recording Radio Signals. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 506—528, December, 1921.)

Describes an instrument originally designed for aeroplane use which enables signals to be seen instead of being read by ear. The apparatus consists of a type of vibration galvanometer in which the vibrator is a thin strip of wire stretched between the pole pieces of two permanent magnets. The currents due to received signals pass through coils placed round the

poles of the magnets. The resulting motion of the vibrator is indicated optically. Signals can be read visually up to a speed of fifteen words per minute but such a method is trying to the eyes so that photography has been used, moving tape methods being employed. In this way signals have been recorded up to a speed of 600 words per minute.

3031. **A. E. Blondel.** Recording Apparatus for Radiotelegraphic Signals. (*U.S. Patent* 1400517, April 26th, 1919. Patent granted December 20th, 1921.)
This patent shows a galvanometer or oscillograph which is adjusted to resonance with an alternating current of any given frequency. The circuit employed includes a receiving antenna system, a detector and a vibrating galvanometer connected in a low resistance tuned circuit. The galvanometer winding may operate the usual mirror for oscillograph reception.

3032. **J. B. Bolitho.** Wireless Receiving Apparatus. (*British Patent* 156330, October 6th, 1919. Patent accepted January 6th, 1921.)
In a "trigger" relay oscillations initiated by incoming signals are periodically quenched by a second valve which intermittently neutralises the reactance between the grid and anode circuits of the "triggered" valve.

3033. **Société Anonyme des Ateliers Brilles frères.** Relays for Synchronising Clocks, etc. (*British Patent* 157438, January 10th, 1921. Convention date, September 26th, 1919, Patent not yet accepted.)
A relay for synchronising clocks and applicable to a wireless receiver for synchronising clocks.

3034. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 147848, July 9th, 1920. Convention date February 8th, 1916. Patent not yet accepted.)
Means for enabling a D.C. relay to be operated by a receiving valve amplifier.

3035. **F. Duroquier.** Radiotelegraphic Recording. (*La Nature*, 49 (1), Supplement pp. 187—188, June 11th; Supplement pp. 195—197, June 18th, 1921.)
Constructional details are given of a relay for use in recording radio messages.

3036. **H. Abraham** and **R. Planiol.** The Use of the Baudot Telegraph in Wireless Communication. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 193—207, June, 1921. *Post Office Electrical Engineers' Journal*, 14, pp. 163—169, October, 1921—Abstract.)
A general *résumé* of earlier work and experiments made in 1920 and 1921.* The second part of the paper gives practical details of the valve transmitting and receiving apparatus. The connections of the modulating valve controlled by the Baudot relay are given as well as details of the amplifying arrangements. It is concluded as a result of the test that the Baudot telegraph apparatus is very easily adaptable to wireless transmission without the need for any modification of its working.

3037. **Toche.** War-time Communications from a Military Telegraphic Point of View. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 246—262, June, 1921.)
Includes some references to the uses of wireless in war-time communication.

3038. **D. A. E. A. Bontekoe.** Einthoven Galvanometer as Photographic Recorder. (*Radio Nieuws*, 4, pp. 49—54, February 1st, 1921.)
A popular illustrated description of the apparatus used years ago in the Lyngby-Knockroe experiments.

3039. **H. de A. Donisthorpe.** A Method of Recording Wireless Signals by Means of a Morse Inker. (*Model Engineer*, 45, pp. 55—56, July 21st, 1921.)
Describes a bridge arrangement of circuit using valves to operate the inker relay.

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* See also RADIO REVIEW Abstract No. 3005, February, 1922.

3040. **S. R. Winters.** A New Automatic Recorder. (*Radio News*, 3, p. 9, July, 1921. *Wireless Age*, 8, pp. 14—15, September, 1921.)

An illustrated description of a recording apparatus, operated by a valve amplifier, which has been developed by the Bureau of Standards.*

3041. **H. Pratt.** Radio Controlled Recorder. (*Wireless Age*, 8, p. 21, April, 1921. *Radioélectricité*, 2, p. 19D, September, 1921—Abstract.)

Briefly describes a mechanical vibrator arranged for inscribing the signals on a rotating drum.

3042. New Wireless Receiver Types Incoming Message. (*Popular Science*, 99, p. 34, October, 1921.)

A short illustrated description of the Creed printing receiver.

3043. **Gesellschaft für drahtlose Telegraphie.** Controlling Relays by Thermionic Valves. (*British Patent* 166881, May 25th, 1921. Convention date July 23rd, 1920. Patent not yet accepted.)

(I). Amplifiers.

(1) General.

3044. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valves. (*British Patent* 162288, April 25th, 1921. Convention date April 27th, 1920. Patent not yet accepted.)

Relates to the use of an iron wire resistance in series with a valve filament to maintain constancy of filament current.

3045. **P. L. Welke.** Audio or Radio Frequency Amplifier. (*Radio News*, 2, p. 441, January, 1921. *Radioélectricité*, 1, p. 115D, April, 1921.)

A comparison of their relative merits for reception purposes.

3046. **H. E. Metcalf.** Power Amplification of Audio Frequencies. (*Radio News*, 3, p. 96, August, 1921.)

(2) Multi-stage Amplifiers (H.F. and L.F.).

3047. **C. W. Rice** [General Electric Company]. Method of and Apparatus for Amplification of Small Currents. (*U.S. Patent* 1401644, July 31st, 1917. Patent granted December 27th, 1921.)

The amplifier shown in this patent employs a plurality of vacuum tubes in which all of the plate circuits are supplied with current from a common source and a high resistance is inserted in each plate circuit. The current to be amplified is applied to the grid circuit of the first amplifier of the series and the current in the plate circuit of that amplifier is varied proportionally. As a result there will be a variation in potential difference between the cathode and anode of the amplifier and this variable potential is applied to the grid circuit of the second amplifier. The variable potential between cathode and anode of the second amplifier is in turn applied to the grid circuit of the third amplifier and so on throughout the series. The plate circuit of the last amplifier includes a telephone receiver or other device for detecting the received signals.

3048. **M. I. Pupin.** Relay. (*French Patent* 507607, December 20th, 1919. Published September 20th, 1920.)

The system described employs a multi-step thermionic amplifier and the electric constants of the circuit are such that reaction between the tubes is destroyed with respect to internal and external disturbances, but not with respect to the desired wave signals. See also *British Patent* 139494 (Radio Review Abstract No. 1174, November, 1920.)

3049. **W. H. F. Griffiths.** Resistance Coupled Thermionic Amplifiers. (*Wireless World*, 8, pp. 833—840, March 5th, 1921. *Technical Review*, 9, p. 79, May 3rd, 1921—Abstract.)

Discusses the amplification factor of resistance coupled amplifiers, and its variation with wavelength.

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* See also Radio Review Abstract No. 3004, February, 1922.

3050. **Siemens and Halske Aktiengesellschaft,** Berlin. Valve Amplifier. (*German Patent* 300144, July 8th, 1916.)

An alternating current amplifier in which the inter-valve linkages are maintained by means of choking coils. The grids of the valves are maintained at favourable potentials by means of these coils and the various anode batteries. (See Fig. 3.)

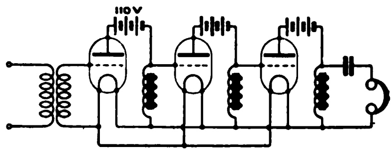

FIG. 3.

3051. **E. V. Appleton** and **Miss Mary Taylor.** A Method of Amplifying Electrical Variations of Low Frequency. (*Electrician*, 85, p. 235, August 27th, 1920.)

Correspondence that refers to the article abstracted in RADIO REVIEW Abstract No. 1173, November, 1920, stating that the writers have conducted similar experiments using somewhat different arrangements and obtaining a low frequency voltage amplification of about 40 with a tube having a natural amplification factor of 10.

3052. **H. J. Round.** Multi-stage Amplifying Receivers. (*British Patent* 149433, May 13th, 1919. Patent accepted August 13th, 1920.)

In a multi-stage amplifier particularly adapted for short wavelengths, but also capable of being used over a range of wavelengths a flat characteristic is obtained by winding the inter-valve transformer with resistance wire. The two windings of each transformer may also be connected to the condensers. Greater stability and less liability to self-oscillation is claimed.

3053. **W. H. Eccles** and **F. W. Jordan.** Thermionic Relays. (*British Patent* 149702, June 21st, 1918. Patent accepted August 26th, 1920.)

The arrangement referred to in this specification is described in RADIO REVIEW Abstract No. 1173, November, 1920.

3054. **P. Jessop.** Indoor Aerials and Choke Coil Amplifiers. (*Radio News*, 2, p. 686, April, 1921.)

Describes a multi-stage amplifier using reactance capacity coupling in place of inter-valve transformers.

3055. **J. Scott-Taggart.** Continuous Wave Multi-stage Receiving Circuits Employing Retroaction and Self-heterodyne Principles. (*Radio News*, 2, pp. 690—748, and 750, April, 1921.)

Describes various arrangements of multi-stage amplifiers with retroaction coupling.

3056. **R. E. Leeault.** Notes on the Functioning and Construction of Resistance Coupled Amplifiers. (*Radio News*, 2, pp. 596 and 648—650, March, 1921.)

Details are given of the construction and mode of operation of an eight-valve resistance capacity coupled instrument.

3057. **W. Schottky.** High Vacuum Amplifiers. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 276—296, October, 1920.)

A long abstract by **Alberti** of Part 2 of Schottky's paper * (*Archiv für Elektrotechnik*, 8, pp. 1—31, and pp. 299—328, 1919). It consists of a discussion of the characteristics of three-electrode valves, their relation to the dimensions and design of the electrodes and the dependence of the amplification upon these various factors.

3058. **K. Mühlbrett.** On Amplifier Transformers. (*Archiv für Elektrotechnik*, 9, pp. 365—390, December 8th, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 220—221, March, 1921. *Elektrotechnische Zeitschrift*, 42, p. 706, June 30th, 1921—Abstract. *Radioélectricité*, 1, pp. 143D—145D, June, 1921—Abstract.)

An important experimental investigation of the properties of transformers for amplifiers.

3059. **E. F. Huth.** Thermionic Detectors and Amplifiers. (*British Patent* 149009, July 12th, 1920. Convention date October 19th, 1915. Patent not yet accepted.)

Relates to methods of coupling thermionic valves in cascade by means of a large inductance

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* Part 1 of this article was abstracted in the *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 326—340, April, 1920.

in the plate circuit of the first valve, and a coupling condenser in series with the grid connection to the next (impedance-capacity coupling). Alternatively the inductance may be replaced by a resistance, and an inductance may be joined in series with the grid coupling condenser.

3060. **S. Loewe** [E. F. Huth Gesellschaft]. Thermionic Valve Amplifiers. (*British Patent* 159213, July 12th, 1920. Convention date October 25th, 1918. Patent not yet accepted.)

To prevent howling and self-oscillation in thermionic valve amplifiers means are provided for maintaining constant the potential of the anode battery, and for eliminating the effects of mutual capacity between the windings of the inter-valve transformers. For the former a large condenser or a small resistance may be joined across the anode battery.

3061. **E. F. Huth.** Wireless Receiving Apparatus. (*British Patent* 149239, July 12th, 1920. Convention date April 26th, 1919. Patent not yet accepted.)

Relates to a multi-stage valve receiver in which the number of valves in circuit can be varied by suitable switching arrangements.

3062. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Amplifiers. (*British Patent* 159322, November 25th, 1919. Patent accepted February 25th, 1921.)

In order to prevent the production of high-frequency oscillations in an amplifier consisting of a number of valves in parallel, a small inductance may be inserted in the grid connection of one or more of the valves.

3063. **S. Loewe.** Thermionic Relays. (*British Patent* 159472, February 23rd, 1921. Convention date February 23rd, 1920. Patent not yet accepted.)

In multi-valve amplifiers in which the energy is transferred from one valve to the next by a resistance coupling, the internal resistance of an extra valve is used as a variable resistance coupling. The internal resistance of this auxiliary valve may be controlled by subjecting its grid to a potential derived from the receiving aerial circuit, or alternatively its grid potential may be controlled by the local heterodyne, so as to reduce interference from disturbing signals.

3064. **J. Robinson** and **H. L. Crowther.** Amplifying Electric Currents. (*British Patent* 159694, December 24th, 1919. Patent accepted March 10th, 1921.)

Relates to an inductance-capacity coupled amplifier using inductances for the plate and grid impedances and a variable coupling condenser. The detector valve may be provided with a retroactive coupling.

3065. **J. Massolle, J. Engl** and **H. Vogt.** Thermionic Valve Amplifiers. (*British Patent* 157733, January 10th, 1921. Convention date April 16th, 1919. Patent not yet accepted.)

A multi-stage amplifier in which the grid-filament of each succeeding valve is joined in series with the anode-filament circuit of the previous valve as indicated in Fig. 4. The arrangement is described in connection with a selenium cell S in the input circuit of the first valve.

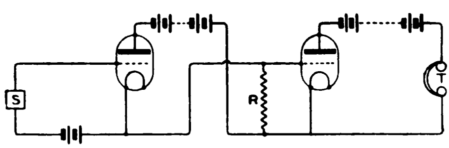

FIG. 4.

3066. **J. Massolle, J. Engl** and **H. Vogt.** Thermionic Valve Amplifiers. (*British Patent* 155744, January 10th, 1921. Convention date October 9th, 1919. Patent not yet accepted.)

An addition to *British Patent* No. 157733, incorporating additional means for controlling the grid potentials.

3067. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Amplifiers and Receivers. (*British Patent* 147446, July 7th, 1920. Convention date May 21st, 1919. Patent not yet accepted.)

Relates to capacity and similar means for obtaining retroaction in a multi-stage amplifier.

3068. **M. Latour.** Thermionic Valve Amplifiers. (*British Patent* 147758, July 8th, 1920. Convention date November 30th, 1918. Patent accepted August 22nd, 1921.)

An addition to *British Patent* 127318.* Switching means are provided for reversing the connections of the inter-valve transformers to reduce howling.

3069. **Siemens and Halske Akt. Gesellschaft.** Thermionic Relays. (*British Patent* 154925, December 6th, 1920. Convention date December 5th, 1919. Patent not yet accepted.)

Relates to the use of damping resistances, etc., to avoid speech distortion in multi-stage L.F. amplifiers.

3070. **E. F. W. Alexanderson** [British Thomson-Houston Company]. Wireless Receiving Apparatus. (*British Patent* 147147, July 7th, 1920. Convention date October 29th, 1913. Patent accepted October 6th, 1921.)

Relates to a cascade series of valves for high frequency amplification in which each grid circuit is tuned so as to obtain greater selectivity.

3071. **I. Langmuir** [British Thomson-Houston Company]. Wireless Receiving Apparatus. (*British Patent* 147148, July 7th, 1920. Convention date October 29th, 1913. Patent not yet accepted.)

A similar arrangement to that outlined in preceding abstract. Part of the series of valves is used for H.F. amplification, one valve for rectifying and the remainder for L.F. amplification. The grid circuits of the last valves are tuned to the group frequency of the signals.

3072. **W. H. Eccles** and **F. W. Jordan.** Thermionic Relays. (*British Patent* 148582, June 21st, 1918. Patent accepted August 5th, 1920.)

A thermionic relay or amplifier comprises a pair or an even number of valves connected in cascade by resistances, with a return connection so that the magnified P.D. along a resistance in the anode circuit of the last valve is communicated to the grid of the first to obtain further amplification by retroaction. (See RADIO REVIEW, 1, pp. 143—146, December, 1919, for further description of this apparatus.)

3073. **H. L. Crowther.** Transformers. (*British Patent* 148679, June 27th, 1919. Patent accepted August 5th, 1920.)

Relates to high-frequency inter-valve transformers having the primary and secondary wound as twin wires in the form of two flat coils. The relative position of the coils can be varied for tuning purposes.

3074. **Siemens and Halske Akt. Gesellschaft.** Thermionic Amplifiers. (*British Patent* 146353, July 2nd, 1920. Convention date July 7th, 1916. Patent accepted October 3rd, 1921.)

Relates to the earthing of suitable points of a cascade amplifier to stop howling.

3075. **L. N. Brillouin.** Rectifier. (*French Patent* 507761, October 19th, 1917. Published September 23rd, 1920.)

The amplifier is intended for use in telephone installations or for wireless telegraphy. A number of tubes are employed having a filament heated by an electric current and plate and grid electrodes. Between the plate electrode of one tube and the grid electrode of the next tube is interposed a transformer in which the primary winding is employed to form part of the secondary winding.

3076. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Valve Amplifier. (*French Patent* 509769, February 10th, 1920. Published November 19th, 1920.) Also **General Electric Company.** (*British Patent* 151346, June 20th, 1919. Patent accepted September 20th, 1920.)

A number of electric valve amplifiers are arranged in cascade and have a shunt connection from the plate to the filament, consisting of a condenser in series with a tuned circuit, the potential differences across the tuned circuit being applied to the grid and filament of the succeeding valve.

3077. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Valve Amplifiers. (*British Patent* 150415, May 29th, 1919. Patent accepted August 30th, 1920.

In a cascade arrangement of thermionic amplifying valves, filters are provided in the

* RADIO REVIEW Abstract No. 83, December, 1919.

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anode supply circuits to minimise low-frequency disturbances, and the last valve of the series is tuned to pick out the second harmonic of the original input frequency in order to reduce the tendency of the whole amplifier to generate oscillations by retroaction.

3078. **J. Erskine-Murray.** Amplifiers. (*British Patent* 152086, July 3rd, 1919. Patent accepted October 4th, 1920.)

In a multi-stage transformer-coupled L.F. amplifier, the valve characteristics and the anode voltages are graduated throughout the amplifier. The first valve has the lowest voltage.

3079. **B. S. Gossling** [General Electric Company, London]. Electric Current Amplifiers. (*British Patent* 155328, August 14th, 1919. Patent accepted December 14th, 1920.)

A cascade amplifier using resistance couplings only. Separate H.T. batteries may be used for each valve, or a common battery may be employed. One arrangement of the latter scheme is indicated in Fig. 5. In this diagram LL represent current-limiting devices, such as iron wire resistances, or low-impedance two-electrode thermionic valves worked above the saturation point. All the current-limiting devices should have the same saturation current. Other modifications are also described.

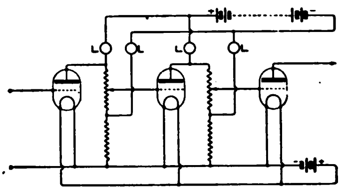

FIG. 5.

3080. **J. Engl, J. Massolle** and **H. Vogt.** Sound Reproduction. (*British Patent* 157436, January 10th, 1921. Convention date July 25th, 1919. Patent not yet accepted.)

Relates to apparatus in which the sound is reproduced electrically by photo-electric cell, microphone or telephone in combination with a valve amplifier.

3081. **Gesellschaft für drahtlose Telegraphie.** Thermionic Relays. (*British Patent* 145630, June 30th, 1920. Convention date November 16th, 1915. Patent accepted September 1st, 1921. *Engineer*, 132, p. 387, October 7th, 1921—Abstract.)

The inter-valve transformers of a cascade amplifier are provided with a metal sheathing (*e.g.* of copper).

3082. **Siemens and Halske Akt. Gesellschaft.** Relays. (*British Patent* 145777, July 2nd, 1920. Convention date October 25th, 1916. Patent accepted April 21st, 1921.)

Relates to screening of cascade amplifiers to reduce whistling or howling.

3083. **Gesellschaft für drahtlose Telegraphie.** Wireless Receiving Apparatus. (*British Patent* 147853, July 9th, 1920. Convention date July 22nd, 1918. Patent not yet accepted.)

Relates to a multi-stage H.F. amplifier with filtering circuits between the valves.

3084. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Amplifiers. (*British Patent* 148183, July 9th, 1920. Convention date November 16th, 1915. Patent not yet accepted.)

Relates to the screening of inter-valve transformers of a cascade amplifier.

3085. **W. Ison.** Ex-military Wireless Apparatus. (*Everyday Science*, 3, pp. 163—165, July, 1921.)

Circuit diagrams are given of the C Mark III., C Mark IV., and A Mark IV. amplifiers.

3086. **R. Evans.** Sound and Voice Magnifiers. (*Sea, Land and Air*, 4, pp. 154—156, May 1st, 1921.)

3087. **N. H. Edes.** The Design of High-frequency Resistance Amplifiers. (*Wireless World*, 9, pp. 233—237, July 9th, 1921.)

A paper read before the Wireless Society of London. (See RADIO REVIEW, 2, p. 481, September, 1921, for Abstract.)

3088. **A. A. C. Swinton.** A Universal Amplifier Suitable for all Wavelengths. (*Wireless World*, 9, pp. 198—204, June 25th, 1921.)

A paper read before the Wireless Society of London describing a six and a two-valve amplifier with interchangeable inter-valve transformers described to the author by H. H. T. Burbury. Construction details are supplied. The discussion which followed the paper is included.

3089. **E. Hoghton** and **Portholme Aircraft Co., Ltd.** Wireless Receiving Systems. (*British Patent* 163810, February 26th, 1920. Patent accepted May 26th, 1921.)

In a high-frequency amplifier for wireless reception, one side of a variable condenser of very small capacity is connected to the grid of the first valve, whilst the other side is connected to the grid of the last H.F. amplifying valve.

3090. New Amplifying Apparatus. (*Radio News*, 2, p. 277, November, 1920.)

An illustrated description with circuit diagrams of apparatus manufactured by **A. H. Grebe & Co., Inc.**

3091. **Société Française pour l'Exploitation des Procédés Thomson-Houston.** Valve Amplifier. (*French Patent* 509843, February 12th, 1920. Published November 20th, 1920.)

A number of valve amplifiers are arranged in cascade and filters are arranged in the anode supply circuits to minimise low-frequency disturbances. The last valve of the series is tuned to pick out the second harmonic of the original frequency so as to reduce the tendency of the whole arrangement to generate oscillations by retroaction.

See also *British Patent* 150415 (RADIO REVIEW Abstract No. 3077).

3092. **Marconi's Wireless Telegraph Co., Ltd.** Receiving Apparatus. (*French Patent* 512780, March 30th, 1920. Published January 31st, 1921.)

The thermionic receiver is particularly adapted for the reception of short wavelengths, though it is stable over a large range. A flat characteristic is obtained by linking a cascade series of valves by means of air core transformers.

See also **H. J. Round** (*British Patent* 149433, and RADIO REVIEW Abstract No. 3052).

3093. **L. M. Hull.** Measurements on Audio-frequency Amplifiers. (*Wireless Age*, 8, pp. 12—16, June, 1921. *Science Abstracts*, 24B, p. 415, Abstract No. 847, August 31st, 1921—Abstract.)

This paper gives the results of a series of measurements of the voltage amplification of audio-frequency amplifiers of various types. The amplifiers dealt with were (1) a two-stage transformer-coupled amplifier with iron core transformers; (2) a two-stage amplifier with air-core transformers; (3) a four-stage resistance-coupled amplifier.

3094. **H. de A. Donisthorpe.** A Simple Form of Low-frequency Amplifier. (*Model Engineer*, 45, p. 185, September 1st, 1921.)

3095. **M. Latour.** Relay. (*French Patent* 512295, April 15th, 1916. Published January 19th 1921.)

The specification describes a method of amplifying high-frequency currents, such as are used in wireless telegraphy or telephony, by vacuum tube relays in combination with iron core transformers. To prevent arcing in the tubes the potentials of certain parts are fixed by connecting them to points on the supply battery.

For further particulars see *British Patent* 127318.

3096. A New Inter-tube Audio-frequency Amplifying Transformer. (*Wireless Age*, 8, pp. 17—18, July, 1921.)

A short description giving details of a low-frequency inter-valve transformer manufactured by the **Radio Corporation of America.**

3097. **F. J. Rumford.** Detector and Three-stage Radio-frequency Amplifier. (*Wireless Age*, 8, pp. 25—26, September, 1921.)

Gives constructional details.

3098. **A. Reisner.** A Transformer-coupled Radio-frequency Amplifier. (*Wireless Age*, 8. pp. 26—27, September, 1921.)

3099. **S. Burdett.** Two-stage Radio-frequency Amplifier. (*Wireless Age*, 8, pp. 27—30, September, 1921.)

3100. **E. H. Armstrong** A New System of Short-wave Amplification. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 3—27, February, 1921. *Sea, Land and Air*, 4, pp. 462—470, September 1st, 1921.)

The problem of receiving weak signals of short wavelength is of importance in direction finding where loop antennæ are very often used. After discussing critically the old methods of attacking this problem the author describes a method of reception developed by the Signal

Corps of the American Army. This scheme is shown diagrammatically in Fig. 6. Here LC represents the usual tuned circuit, H a separate heterodyne and D_1 a detector. The beats between the received signals and the heterodyne are arranged to be of ultra-audio or radio-frequency and after rectification by D_1 are amplified by A as such. The amplified signals are then modulated at an audio-frequency by M and the resulting oscillations rectified by D_2 and received in T.

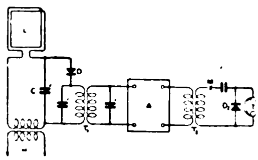

FIG. 6.

Complete triode circuits of the types of H.F. amplifiers, which have been used successfully with this method are given. (See also RADIO REVIEW Abstract No. 1668, April, 1921.)

In the discussion of the paper, a lengthy theoretical consideration of the subject is contributed by **A. S. Blatterman.**

3101. The Construction of a Frame Aerial Receiving Set. (*L'Électricité pour Tous*, 3, pp. 253—257, September 30th, 1921.)

3102. **E. O. Hulburt.** The Detecting Efficiency of the Resistance Capacity Coupled Electron Tube Amplifier. (*Physical Review*, 18, pp. 165—177, September, 1921; p. 140, August, 1921—Abstract.)

Theoretical formulæ are derived and compared with results of measurements made by using a condenser potential divider to vary the high-frequency input voltage and a sensitive galvanometer to measure the rectified high-frequency component output plate current. Satisfactory agreement was found and the effect of a third tube was determined experimentally. Curves are also given comparing the detecting efficiency of resistance coupled and tuned transformer-coupled amplifiers.

3103. **C. A. Hoxie** [General Electric Company]. Amplifying System. (*U.S. Patent* 1382914, May 10th, 1920. Patent granted June 28th, 1921.)

A multi-stage amplifier designed to avoid undesirable production of oscillatory currents in cascade amplification and to be highly selective of a particular frequency without producing an appreciable amplification of currents of other frequencies. The different stages of the amplifier have substantially no electrostatic coupling and are shielded to entirely prevent any feed-back action from an output circuit to the input circuit of a preceding stage.

3104. **S. E. Adair** [International Radio Telegraph Company]. Amplifier. (*U.S. Patent* 1383275, August 14th, 1919. Patent granted July 5th, 1921.)

Amplifier designed to be free from oscillation disturbances which result in producing howling, and is also free from paralisation due to the production of negative charges on the grids of the tubes. In this amplifier the vacuum tubes in the several stages are connected in one branch of a series of Wheatstone bridge circuits, as indicated in Fig. 7.

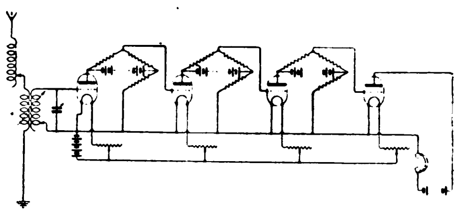

FIG. 7.

3105. **M. C. A. Latour.** Amplifying Apparatus. (*U.S. Patent* 1382738, June 8th, 1918. Patent granted June 26th, 1921.)

Amplifying apparatus constructed to eliminate objectionable noises due to the setting up of oscillations. (See corresponding *British Patent* 127318, RADIO REVIEW Abstract No. 83, December, 1919.)

3106. **H. C. Harrold.** Thermionic Valves and their Application to Wireless Telegraphy. (*Signal*, 1, pp. 19—20, July; pp. 9—13, August, 1921.)

A continuation of the series of articles referred to in Abstract No. 1667, April, 1921.

3107. **G. A. Mathieu.** Thermionic Valve Amplifying Apparatus. (*British Patent* 166913, May 3rd, 1920. Patent accepted August 4th, 1921.)

Relates to the design of inter-valve transformers for multi-stage amplifiers.

3108. **Arthur Haddock** [Western Electric Company, Inc.]. Vacuum Tube Circuits. (*U.S. Patent* 1396745, May 19th, 1919. Patent granted November 15th, 1921.)

This patent relates to a multi-stage amplifier. Switching means are provided for varying the number of effective tubes between the input and output circuit of the amplifier and also for regulating the potential between the incoming line and one of the tubes. The object of the circuit is to vary the amplification to any desired degree between the input circuit and the output circuit.

3109. **L. De Forest** [De Forest Radio Telephone and Telegraph Company]. Selective Audion Amplifier. (*U.S. Patent* 1397575, April 9th, 1915. Patent granted November 22nd, 1921.)

This patent describes a vacuum tube amplifier having in its output circuit a plurality of oscillating circuits associated therewith to amplify impressed currents of certain input frequencies to a greater degree than impressed currents of other frequencies.

3110. **W. Schottky.** Hard Valve Amplifiers. Part 3. Multiple Grid Valves. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 344—371, November, 1920.)

A very full abstract by Alberti of Schottky's paper in *Archiv für Elektrotechnik*, 8, pp. 1—31, 299—328, 1919.

This part deals exclusively with valves having two grids between the filament and anode. The theory is discussed and experimental characteristics given for various types of double grid valves.*

(4) MISCELLANEOUS APPLICATIONS OF AMPLIFIERS.

3111. On the Use of Amplifiers on Submarine Cables. (*Annales des Postes, Télégraphes et Téléphones*, 10, p. 316, June, 1921.)

A brief note with regard to researches carried out by the French Postal Telegraph Administration.

3112. **K. Höpfner.** Amplifiers in Telephone Cables. (*Telegraphen- und Fernsprech-Technik*, 9, pp. 126—129, October; pp. 139—141, November, 1920. *Annales des Postes, Télégraphes et Téléphones*, 10, pp. 346—355, June, 1920—Abstract.)

3113. **V. H. Laughter.** A Method of Producing Musical or Other Suitable Notes. (*Radio News*, 2, p. 363, December, 1920.)

3114. The Installation of Amplifiers on the Brest-Dakar Cable. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 491—492, September, 1921.)

3115. Long-distance Telephony in France. (*Annales des Postes, Télégraphes et Téléphones*, 10, pp. 492—500, September, 1921.)

(5) AND (8) MICROPHONIC, ETC., AMPLIFIERS; POWER AMPLIFIERS.

3116. **D. Reichinstein.** Reinforcing Direct Currents. (*British Patent* 159499, January 21st, 1921. Convention date February 25th, 1920. Patent not yet accepted.)

Relates to a combination of electrolytic cell and commutator so that the polarisation E.M.F. reinforces the feeble rectified current in a radio receiver.

3117. **D. McLennan** [Creed & Company]. Electric Relays. (*British Patent* 150025, May 14th, 1919. Patent accepted August 16th, 1920.)

A microphone relay.

3118. **G. Gatis.** Crystal Amplifier. (*Radio News*, 3, pp. 17 and 70, July, 1921.)

Describes an arrangement of a multi-stage amplifier using crystal detectors in place of valves to perform the amplification.

3119. **Gesellschaft für drahtlose Telegraphie.** Producing Electric Oscillations. (*British Patent* 147431, July 7th, 1920. Convention date December 31st, 1915. Patent accepted September 15th, 1921.)

High-frequency oscillations are produced in the output circuit of a thermionic valve containing conducting gas, by supplying oscillations of the required frequency but of small amplitude to its input circuit.

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* See RADIO REVIEW Abstracts Nos. 235, March, 1920, and 3057 in this issue for references to previous parts.

(J.) Subsidiary Wireless Apparatus.

(1) Power Supply; H.T. Batteries, etc.

3120. **K. Schmidt.** Generators for Wireless Telegraphy. (*Elektrotechnische Zeitschrift*, 42, pp. 245—249, March 17th; pp. 280—284, March 25th, 1921. *Revue Générale de l'Électricité*, 9, p. 167D, May 21st, 1921.)

A general summary of the generators both for D.C. and A.C. used in various systems of wireless telegraphy. Most consideration is given to alternators for about 500 cycles per second, the various types being discussed. Iron loss curves are given for different thicknesses of lamination at various frequencies. Photographs and particulars are given of small units intended for aircraft wireless, also of petrol-electric sets designed by the author who is the chief engineer of the Lorenz Company. In the section on radio-frequency alternators there are vague references to a greatly improved system of frequency transformation devised by the author but no details are given.

3121. **E. F. Huth.** Portable Electrical Machine. (*German Patent* 315727, May 11th, 1918.)

A portable electric generator for use in wireless telegraphy. The instrument is carried by means of shoulder straps and is worked by hand.

3122. **E. F. Huth.** Inductor Alternators. (*British Patent* 148320, July 9th, 1920. Convention date February 1st, 1916. Patent accepted July 14th, 1921.)

The exciter an inductor alternator for use for supplying W.T. apparatus on aircraft is increased in size so as to enable it to supply the lamps, searchlight, etc., on the machine. Alternatively such circuits may be fed from a special commutator winding included in the slots of the main alternator.

3123. **H. G. Wheeler.** Balance of High-speed Electric Dynamos and Motors. (*Electrician*, 87, pp. 136—138, July 29th, 1921.)

3124. **M. Héroux.** On the Use of Alternating Current for Lighting Valve Filaments. (*La Nature*, 49(2), Supplement pp. 119—120, October 15th, 1921.)

A circuit diagram is given for this purpose, the main feature being the use of a potentiometer across the valve filament, the slider being connected in the grid circuit.

3125. **A. H. Lynch.** Is the Storage Battery to be Replaced as a Source of Auxiliary Power for Marine Radio? (*Radio News*, 3, p. 280, October, 1921.)

Describes and illustrates a petrol-driven auxiliary set for use on shipboard.

3126. **K. Schmidt.** D.C. and A.C. Generators for Wireless Telegraphy. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 2—28, July, 1921.)

A general review of the various types of machines specially employed in radiotelegraphy with special reference to some of telephonic frequencies designed by the author for the Lorenz Company. Photographs, sections and characteristic curves are given for some of these machines.

(2) and (3) Transformers and Power Rectifiers.

3127. **Gesellschaft für drahtlose Telegraphie.** High-frequency Power Transformers. (*British Patent* 147754, July 8th, 1920. Convention date July 29th, 1915. Patent accepted May 12th, 1921.)

3128. **C. H. Thordarson.** Electrical Transformer. (*U.S. Patent* 1378151, November 6th, 1916. Patent granted May 17th, 1921.)

3129. **E. F. Huth.** Wireless Signalling Arrangements. (*British Patent* 149198, July 12th, 1920. Convention date October 13th, 1917. Patent not yet accepted.)

The same thermionic valve is arranged to be used either for transmitting or receiving. A commutator arrangement is provided, by which the aerial may be coupled with the plate circuit for transmitting or with the grid circuit for receiving.

3130. **L. M. Clement** [Western Electric Company]. Oscillation Generating System. (*U.S. Patent* 1395390, September 30th, 1918. Patent granted November 1st, 1921.)

The object of this invention is to provide a vacuum transmitter with means for varying the frequency of the oscillator and simultaneously to automatically provide the proper plate coupling and feed-back coupling for any particular frequency at which the oscillator is set to

operate. A form of wave change switch is employed which cuts in contacts to vary the inductances in the plate circuit and likewise to change the capacity between the grid and cathode circuit of vacuum tube.

(4) POWER RECTIFIERS, ETC.

3131. **J. Kremenezky.** Electrolytic Valves. (*British Patent* 150958, September 9th, 1920. Convention date March 14th, 1918. Patent not yet accepted.)

Relates to the construction of an electrolytic rectifying valve.

3132. **Société des Ateliers de Constructions Électriques du Nord et de l'Est.** Electric Rectifier. (*British Patent* 158237, January 10th, 1921. Convention date December 13th, 1918. Patent not yet accepted.)

3133. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Thermionic Valves. (*British Patent* 158458, January 19th, 1920. Patent accepted February 10th. 1921.)

The rectifying valve has an anode and an incandescent tungsten cathode in a filling consisting mostly of helium.

3134. **J. Slepian** and **E. Justin** [Metropolitan-Vickers Electrical Company]. Electrolytic Rectifier. (*British Patent* 155579, December 2nd, 1920. Convention date December 9th, 1919. Patent not yet accepted.)

3135. **Naamlooze Vennootschap Philips' Gloeilampenfabrieken.** Thermionic Valve Rectifiers. (*British Patent* 154872, May 8th, 1920. Convention date December 2nd, 1919. Patent accepted May 5th, 1921.)

All the electrodes of the rectifier are in the form of filaments so that if one is burnt out it can subsequently be used as an anode.

3136. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Electric Discharge Apparatus. (*British Patent* 152694, March 4th, 1916. Patent accepted October 28th, 1920.)

Relates to rectifying and similar apparatus in which the cathode is maintained incandescent by an arc discharge inside the tube, which is filled with mercury or similar vapour, or with an inert gas.

3137. **Siemens-Schuckertwerke.** Rectifiers. (*British Patent* 145029, June 14th, 1920. Convention date May 15th, 1919. Patent accepted February 3rd, 1921.)

An addition to *British Patent* 142465 * relating to the use of A.C. of 500 to 5,000 $\sim$, and to the heating of the valve filament from the same A.C. source.

3138. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Rectifier (*French Patent* 507198, December 9th, 1919. Published September 7th, 1920.)

The rectifier has a current and pressure range similar to those of mercury vapour rectifiers. It consists of a glass envelope containing a heated refractory cathode, and one or more anodes of large heat-dissipating capacity. The glass envelope contains an inert gas such as nitrogen, argon or neon. See also *British Patent* 5557/1915.

3139. **J. F. G. P. Hartmann.** Rectifier for Alternating Current. (*French Patent* 508996, March 20th, 1919. Published October 28th, 1920. *British Patent* 130936, April 19th, 1919. Convention date November 14th, 1918. Patent accepted August 14th, 1919.)

The patent is based on a corresponding Danish patent, and describes a rectifier for alternating current of the mercury jet type.

3140. **Siemens-Schuckertwerke.** Rectifying Apparatus. (*British Patent* 145423, June 17th, 1920. Convention date October 23rd, 1915. Patent accepted September 15th, 1921.

3141. **Brown, Boveri et Cie. Akt. Gesellschaft.** Converting Electric Currents. (*British Patent* 151612, September 22nd, 1920. Convention date September 22nd, 1919. Patent not yet accepted.)

Rectifier apparatus.

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* RADIO REVIEW Abstract No. 809, September, 1920.

3142. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Electric Discharge Devices. (*British Patent* 157041, March 4th, 1916. Patent accepted January 20th, 1921.)

The cathode of a rectifier is maintained incandescent by the discharge itself.

3143. **Siemens-Schuckertwerke.** Rectifiers. (*British Patent* 145481, June 21st, 1920. Convention date June 10th, 1916. Patent accepted November 4th, 1920.)

3144. **Siemens-Schuckertwerke.** Rectifier. (*British Patent* 145677, June 30th, 1920. Convention date October 29th, 1915. Patent accepted September 30th, 1921.)

3145. **A. W. Hull** [British Thomson-Houston Company]. Converting Electric Currents. (*British Patent* 148129, July 9th, 1920. Convention date December 22nd, 1915. Patent accepted September 22nd, 1921.)

A constant potential direct current is obtained from a variable voltage source by means of series and shunt devices which offer respectively high and low impedances to the alternating components of the current.

3146. **Brown, Boveri et Cie. Akt. Geselischaft.** Rectifiers. (*British Patent* 163686, April 4th, 1921. Convention date May 15th, 1920. Patent not yet accepted.)

3147. **D. R. Clemons.** A New Device to obtain A.C. from a D.C. Source. (*Radio News*, 2, p. 771, May, 1921.)

A rotary variable resistance arrangement.

3148. **R. Vallette.** Converting Electric Currents. (*British Patent* 164721, May 2nd, 1921. Convention date June 20th, 1920. Patent not yet accepted.)

Alternating currents are rectified by means of a thermionic valve in series with a condenser. The alternating current serves to heat the valve filament through a transformer. The alternating current may be supplied to the valve either directly or through a transformer. A condenser is placed in shunt with the direct current supply terminals.

3149. **W. J. L. Chinn.** Rectifier. (*French Patent* 512527, March 29th, 1920. Published January 25th, 1921.)

This specification describes a mercury vapour rectifier.

3150. **Siemens Schuckertwerke.** Rectifiers. (*French Patent* 512518, March 29th, 1920. Published January 25th, 1920.)

This specification describes a high-tension rectifier for alternating currents.

3151. **Siemens Schuckertwerke.** Rectifiers. (*French Patent* 512517, March 29th, 1920. Published January 25th, 1920.)

This specification describes a high-tension rectifier for alternating currents.

3152. A New Rectifier Scheme. (*Q.S.T.*, 5, pp. 23—24, September, 1921.)

Describes an electrolytic rectifier with sliding condensers.

3153. **T. W. Benson.** Construction of a Synchronous Rectifier. (*Wireless Age*, 8, pp. 22—23, April, 1921.)

3154. **W. T. Birdsall** [Westinghouse Lamp Company]. Vacuum Rectifier. (*U.S. Patent* 1388793, January 5th, 1917. Patent granted August 23rd, 1921.)

A vacuum type converter wherein the discharge is not dependent upon an auxiliary heating current through a filamentary cathode. The discharge is maintained by virtue of electron emission and operates in the absence of auxiliary means for maintaining one or more electrodes at an electron-emitting temperature. The apparatus comprises two filamentary electrodes, means for supplying either a direct or alternating current across the electrodes and means for initially passing a heating current through each of the electrodes until they are brought to an electron-emitting temperature.

3155. **H. H. Smith.** The Hulbert Transrectiformer. (*Radio News*, 3, p. 294, October, 1921.)

(5) Choke Coils and Protective Apparatus.

3156. **G. Faccioli** and **H. G. Brinton.** High-frequency Absorbers. (*General Electric Review*, 24, pp. 444—454, May; pp. 656—658, July, 1921.)

The article discusses the effect of resistance in series with a condenser for use as a " high-

frequency absorber." It is shown that such an absorber is a valuable adjunct to a lightning arrester for protection against transient disturbances which are of too low a voltage to spark over the arrester but which would otherwise be dangerous on account of their steep wave-front. The second part of the article discusses the similar case of resistance and inductance in series.

3157. **J. Bethenod.** On the Design of Filters and Choke Coils. (*Radioélectricité*, 1, pp. 629—632, June; 2, p. 11, July, 1921. *Annales des Postes, Télégraphes et Téléphones*, 10 pp. 510—518, September, 1921.)

A mathematical discussion of the design of iron core choke coils and protective devices used for stopping the passage of high-frequency currents in the circuit. Two cases are considered: (1) given the dimensions of the iron core to determine the number of turns which will produce the maximum self-inductance when a given steady continuous current is flowing through the winding; and (2) given the dimensions of the iron core and the number of turns on the winding to determine the air gap which will give the maximum self-inductance when a given continuous current is traversing the winding.

3158. **S. Edgar.** A Common Cause of Induction from the Ship's Dynamo and its Remedy. (*Radio News*, 3, p. 286, October, 1921.)

(6) TELEPHONES, AND TELEPHONE TRANSFORMERS.

3159. **S. Hockly.** Telephone Receivers and Transmitters. (*British Patent* 161241, December 29th, 1919. Patent accepted March 29th, 1921.)

Relates to constructional details of telephones and microphones.

3160. **V. F. Feeny** [Magnavox Company]. Telephone Transmitters. (*British Patent* 161277, January 6th, 1920. Patent accepted March 6th, 1921.).

Relates to a transmitter in which both sides of the diaphragm are exposed to the sound waves.

3161. **H. P. Rees.** Telephone Receivers. (*British Patent* 150956, April 15th, 1920. Patent accepted September 16th, 1920.)

Relates to receiving telephones having the windings tapped to adjust the number of turns in circuit.

3162. **A. Johnsen** and **K. Rahbek.** Electrostatic Attraction. (*Electrical Industries*, 21, p. 658, May 25th, 1921. *Electrical Review*, 88, p. 722, June 3rd, 1921. *Engineer*, 131, p. 597, June 3rd, 1921.)

An abstract of a lecture delivered before the Institution of Electrical Engineers. (See RADIO REVIEW, 2, p. 373, July, 1921.)

3163. **A. A. Campbell Swinton.** The Johnsen-Rahbek Electrostatic Loud-speaking Telephone and Relay. (*Electrical Review*, 88, p. 710, June 3rd, 1921.)

Discussion *re* matter referred to in Abstract No. 3162, and pointing out prior discovery of the phenomenon by Elisha Gray.

3164. Electrostatic Adhesion. (*Electrical Review*, 88, p. 721, June 3rd, 1921. Also pp. 744—745, June 10th, 1921.)

Extracts from an article by **W. H. Preece** in the *Telegraphic Journal* of September 1st, 1877, dealing with experiments of Elisha Gray; also from same journal of April 1st, 1879, describing Edison's telephone receiver. (See RADIO REVIEW Abstracts Nos. 3162 and 3163.)

3165. The Johnsen-Rahbek Effect. (*Engineer*, 131, p. 614, June 10th, 1921. *The Times Engineering Supplement*, 17, No. 560, p. 197, June, 1921. *La Nature*, 49(2), pp. 87—88, August 6th, 1921—Abstract. *Engineering*, 111, pp. 685—686, June 3rd, 1921. *Nature*, 107, p. 439, June 2nd, 1921—Abstract. *Radio Nieuws*, 4, pp. 232—233, August, 1921—Abstract. *Radio Review*, 2, p. 373, July, 1921—Abstract. *Radio News*, 3, p. 286, October, 1921—Abstract.)

A summary of the comments made about this effect (RADIO REVIEW Abstracts Nos. 3162, 3163, 3164.)

3166. **R. Appleyard.** Retentive Force and a Tale of a Tub. (*Electrical Review*, 88, p. 748, June 10th, 1921; also *The Times*, No. 42733, p. 5, May 30th, 1921.)

Further correspondence with reference to Johnsen and Rahbek's telephone, the author's

experiments, Edison's telephone receiver and Elisha Gray's experiments. (See also RADIO REVIEW Abstracts 3162, 3163, 3164, 3165, 3179, in this issue.)

3167. **W. F. Barrett.** A New Electric Device. (*The Times*, No. 42734, p. 6, May 31st, 1921.)

Correspondence *re* Johnsen and Rahbek's electrostatic telephone, and some experiments of the author made in 1880.

3168. **C. Kearton** and **G. B. Riley.** Telephone Receivers. (*British Patent* 159776, December 19th, 1919. Patent accepted March 10th, 1921.)

3169. **Siemens and Halske.** Telephones. (*British Patent* 159897, March 9th, 1921. Convention date March 9th, 1920. Patent not yet accepted.)

A loud-speaking receiver also applicable to under-water signalling.

3170. **Siemens and Halske.** Telephones. (*British Patent* 159904, March 10th, 1921. Convention date March 10th, 1920. Patent not yet accepted.)

Constructional details of a loud-speaking telephone.

3171. **R. L. Murray** [Telephone Manufacturing Company]. Telephones. (*British Patent* 160243, December 13th, 1919. Patent accepted March 14th, 1921.)

3172. **G. Seibt.** Telephone Receiver. (*British Patent* 147153, July 7th, 1920. Convention date March 1st, 1916. Patent not yet accepted.)

A special construction for the pole pieces.

3173. **The Magnavox Company.** Telephone Transmitter. (*French Patent* 508443, January 15th, 1920. Published October 11th, 1920.)

The transmitter has both sides of the diaphragm exposed to sound and the plane of the electrodes is oblique to that of the diaphragm, so that the transmitter operates in either a vertical or horizontal position.

See also *British Patent* 161277 (RADIO REVIEW Abstract No. 3160.)

3174. **K. Rahbek** and **F. A. Johnsen.** Telephonic Apparatus. (*British Patent* 146747, September 6th, 1919. Patent accepted July 15th, 1920.)

An addition to *British Patent* 144761, covering loud-speaking telephones of the type described in RADIO REVIEW, p. 373, July, 1921.

3175. **K. Rahbek** and **F. A. Johnsen.** Telephones. (*British Patent* 144761, March 6th, 1919. Patent accepted June 7th, 1920.)

Relates to electrostatic loud-speaking telephones of the type described in RADIO REVIEW, 2, p. 373, July, 1921.

3176. **J. H. Dellinger.** The Radio Work of the Department of Commerce. (*Q.S.T.*, 4, pp. 18—21, June, 1921.)

An account of the work of the U.S. Radio Inspection Service and the Bureau of Standards.

3177. **J. Valasek.** Piezo-electric and Allied Phenomena in Rochelle Salt. (*Physical Review*, 17, pp. 475—481, April, 1921. *Science Abstracts*, 24A, p. 448, Abstract No. 1152, June 30th, 1921—Abstract.)

3178. **P. R. Coursey.** Loud-speaking Telephones—II. (*Wireless World*, 9, pp. 225—228, July 9th; pp. 256—261, July 23rd; pp. 289—292, August 6th; pp. 311—314, August 20th, 1921.)

A general consideration of electrostatic attraction effects and their application to sound production culminating in a description of the apparatus of **A. Johnsen** and **K. Rahbek.**

3179. **A. Johnsen** and **K. Rahbek.** A New Electrostatic Phenomenon and its Applications. (*Elektroteknisk Tidsskrift*, 33, pp. 269—272, November 25th, 1920.)

A description of the electrostatic adhesion effects referred to on p. 373 of the July, 1921, issue of the RADIO REVIEW together with some of their applications (see also below).

3180. **A. Gradenwitz.** A New Phenomenon of Electrical Attraction. (*Popular Science Monthly*, 99, p. 26, July, 1921.)

Deals with the Johnsen and Rahbek apparatus. (See RADIO REVIEW Abstracts Nos. 3162, 3163, 3164, 3165, 3174, 3175, 3178 and 3179.)

3181. **J. Corver.** The Magnavox Loud-speaking Telephone Receiver. (*Radio Nieuws*, 4, pp. 75—77, March, 1921.)

This American apparatus consists of a pot electromagnet in the circular gap of which is the moving coil carrying the speech current and fixed to the centre of the diaphragm.

3182. The Electro-dynamic Receiver. (*Radio News*, 2, p. 434, January, 1921.)
An illustrated description of the Magnavox loud-speaking telephone.

3183. **C. Stille.** Telephone Receivers. (*British Patent* 10669/1915, July 22nd, 1915. Addition to *British Patent* 9644/1913, dated April 24th, 1912. Patent published July 11th, 1921.)
A pneumatic relay arrangement operated by a telephone receiver.

3184. "The Phonetron." (*Radio News*, 3, p. 13, July, 1921.)
A short note describing a new pattern of loud-speaking telephone.

3185. The Vocaloud. (*Radio News*, 3, p. 102, August, 1921.)
A short note describing and illustrating a new pattern of loud-speaking telephone.

3186. **J. Brun.** Telephone Receivers for Radio Purposes. (*Radioélectricité*, 2, pp. 6—11 July, 1921.)
Descriptions are given of various patterns of telephone receiver.

3187. Loud-speaking Telephone Equipment. (*Science and Invention*, 9, p. 320, August, 1921. *Electrical World*, 78, p. 156, July 23rd, 1921.)
An illustration of a multiple horn loud-speaking apparatus mounted on a tower. The energy of the amplification is said to be 10^{10}. An illustration and circuit diagram of the valve amplifying apparatus are also given.

3188. **P. R. Coursey.** The Piezo-electric Properties of Rochelle Salt Crystals. (*Radio Review*, 2, pp. 480—481, September, 1921.)

3189. **R. Atkinson.** Operating Notes on Electrolytic Rectifiers. (*Q.S.T.*, 5, p. 27, September, 1921.)

3190. **H. Marchand.** The Magnavox. (*La Nature*, 49, pp. 252—254, October 15th, 1921—Abstract.)
See RADIO REVIEW Abstract No. 1178, November, 1920.

3191. **C. T. Zahn.** The High-frequency Impedance of Radio Telephone Receivers. (*Physical Review*, 18, p. 150, August, 1921.)
An abstract of a paper read before the American Physical Society giving the results of measurements on various types of head telephone receivers. It was found that for all receivers there was a critical frequency where the reactance changed sign and near which the resistance was a maximum. This critical frequency varied between 8,000 and 50,000 cycles per second the maximum values of resistance and capacity being of the order of 100,000 ohms.

(7) MATERIALS FOR CONSTRUCTION OF RADIO APPARATUS.

3192. **B. Speed** and **C. W. Elmen.** Magnetic Properties of Compressed Powdered Iron. (*Journal of the American Institute of Electrical Engineers*, 40, pp. 594—609, July, 1921. *Science Abstracts*, 24B, p. 432, Abstract No. 874, September 30th, 1921—Abstract.)
Discusses the manufacture and measurement of the magnetic properties of cores constructed of compressed powdered iron for use in inductances and transformers.

3193. **G. B. Crouse** and **I. H. Mills.** Receiving Panel. (*U.S. Patent* 1370093, March 10th, 1919. Patent granted March 1st, 1921.)

3194. **W. Steinhaus.** Dielectric Losses in Colophonium, Wax, and Similar Materials. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 29—33, July, 1921. *Science Abstracts*, 24B, pp. 463—464, Abstract No. 429, September 30th, 1921—Abstract.)

3195. **H. H. Poole.** On the Electrical Conductivity of some Dielectrics. (*Philosophical Magazine*, 42, pp. 488—501, October, 1921.)
A method is described of testing the conductivity by rectified high voltage currents. Results are given for mica, glass, paraffin wax, shellac and celluloid.

3196. **W. Steinhaus.** The Dielectric Losses in Resin, Wax, and Similar Substances. (*Jahrbuch Zeitschrift für drahtlose Telegraphie und Telephonie*, 18, pp. 29—33, July, 1921.)
Results of experiments made in 1916 under M. Wien to discover the cause of the great losses in glass condensers made with specially good glass. The cause was found in the wax

which was employed to prevent brush discharge from the edges of the electrodes. The losses in various waxes were then determined by finding the decrement of a condenser made up with the material as dielectric. In many materials the losses were found to increase very rapidly with increasing temperature until the melting point was reached, when the losses fell to a very small value. Paraffin and ozokerite do not show this phenomenon.

3197. **E. Schott.** High-frequency Losses in Glass and some other Dielectrics. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 82—122, August, 1921.)

A very thorough investigation of the losses at radio frequencies in condensers made up with various qualities of glass. Every care appears to have been taken to avoid experimental errors. The loss expressed as an angle varies from 22·6 to 1·39 minutes in various qualities of glass. Approximate compositions of the glasses are given. The losses are greatest in those containing large percentages of sodium and potassium. Some other dielectrics were tried and the author gives the following table : glass 1·5′ to 25′ (highest value 90′), quartz 0·4′, good mica 0·6′, reconstructed amber 18′, presspahn about 100′. The effects of variations of frequency and temperature were also investigated and curves are given of the results.

(9) Resistances for Valve Circuits, etc.

3198. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Resistance. (*French Patent* 509747, November 9th, 1918. Published November 18th, 1920.)

The specification describes a method of manufacturing high resistance units of constant value. The resistance comprises a film of conducting material on the interior of an exhausted glass tube. The film is produced by volatilising a metal within the tube. Wires are sealed in the tube to form connecting terminals.

3199. **F. Pellin** and **G. Pelletier.** Electric Resistances. (*British Patent* 165099, June 2nd, 1921. Convention date June 22nd, 1920. Patent not yet accepted.)

Non-inductive resistances of predetermined value are prepared by depositing a thin layer of metal on an insulating support by cathodic bombardment in a vacuum.

3200. **P. H. Boucheron.** Concerning Grid Leaks. (*Wireless Age*, 8, p. 15, April, 1921.)

Emphasises the importance of the proper resistance of the grid leak and sets out various standardised values.

3201. A Constant Resistance Unit. (*Wireless Age*, 8, p. 32, July, 1921.)

The resistance unit described can be constructed for practically any value between 1 ohm and 1 megohm. It consists of a thin film of platinum and gold deposited chemically on a strip of clear mica.

(10) Speed Regulating Apparatus for H.F. Machines.

3202. A Sensitive Governor for Electric Motors driving High-frequency Alternators. (*Zeitschrift des Vereines deutsche Ingenieure*, 65, p. 598, June 4th, 1921.)

A short description of a relay governing arrangement.

3203. **Dornig** and **Kühn.** Speed Regulation of Motors driving Radio-frequency Alternators. (*Elektrotechnische Zeitschrift*, 42, p. 1019, September 8th, 1921.)

Correspondence concerning priority in the development of the frequency doubling transformer and of the centrifugal speed regulator.

3204. **E. F. W. Alexanderson** [General Electric Company]. System of Radio Communication. (*U.S. Patent* 1400847, December 31st, 1918. Patent granted December 20th, 1921.)

This patent shows a speed regulating mechanism for a high-frequency alternator employed at the transmitter in a radio system. The high-frequency alternator shown in the drawings is driven by a three-phase electric motor supplied with power from a distribution system, and a regulator relay is employed to control the power delivered to the shaft of the alternator. The regulator comprises a tuned circuit energised by current derived from the high-frequency alternator. A rectifier is associated with the tuned circuit and delivers rectified current to the relay for controlling the power to the motor. Various means are described for amplifying the variations of energy acting upon the regulator relay whereby great sensitivity is obtained to maintain constant the speed of the alternator.

(11) AND (12) ACCESSORIES FOR RADIO CIRCUITS.

3205. **Gesellschaft für drahtlose Telegraphie.** Conductors for H.F. Currents. (*British Patent* 147447, July 7th, 1920. Convention date May 28th, 1919. Patent accepted April 7th, 1921.)

3206. **A. K. Macrorie** and **H. Morris-Airey.** Holders for Thermionic Valves. (*British Patent* 162772, February 2nd, 1920. Patent accepted May 2nd, 1921.)

3207. **H. P. Doule** [Connecticut Telephone and Electric Company]. Vacuum Tube Base. (*U.S. Patent* 1374832, September 27th, 1919. Patent granted April 12th, 1921.)

3208. **R. F. Gowens** [De Forest Radio Telephone and Telegraph Company]. Inductance Coil Mounting. (*U.S. Patent* 1365170, August 20th, 1919. Patent granted January 11th, 1921.)

3209. **R. M. Allen** [Western Electric Company]. Mounting for Vacuum Tubes. (*U.S. Patent* 1401121, May 24th, 1918. Patent granted December 27th, 1921.)

This invention relates to a resilient support for vacuum tubes to reduce the effect of an external vibration upon the structure of the tube.

(K.) Aerials and Earthing Systems.

(1) GENERAL.

3210. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Aerials. (*French Patent* 507653, December 23rd, 1919. Published September 21st, 1920.)

The aerial is of the type having horizontal wires and these are grounded through additional vertical wires. The generator is an oscillating arc generator and the ground connections comprise a wire network mounted a short distance above the earth. See also *British Patent* 144075 (RADIO REVIEW Abstract No. 2037, July, 1921).

3211. **C. S. Franklin.** Aerials. (*British Patent* 155330, August 14th, 1919. Patent accepted December 14th, 1920.)

Relates to the tuning of a distant loop aerial by the use of a series of tight-coupled untuned circuits between the distant aerial and the tuning station. Earthed screens are used between the coupling transformers to prevent oscillations being set up on the connecting circuits.

3212. **Gesellschaft für drahtlose Telegraphie.** Wireless Transmitters. (*British Patent* 148180, July 9th, 1920. Convention date November 6th, 1918. Patent not yet accepted.)

A filtering circuit to eliminate harmonics from the transmitted waves.

3213. **H. J. Round.** Wireless Signalling. (*British Patent* 164506, March 11th, 1920. Patent accepted June 13th, 1921. *Engineering*, 123, p. 81, July 15th, 1921—Abstract.)

An arrangement for counterbalancing automatically the variations in the wavelength of an aerial due to such causes as swinging in the wind during transmission.

3214. **H. de A. Donisthorpe.** Some Notes on Aerial and Earth Systems. (*Model Engineer*, 45, pp. 160—161, August 25th, 1921.)

3215. **M. Buchbinder.** The Effect of Counterpoise on Antenna Resistance. (*Radio News*, 3, p. 197, September, 1921.)

3216. **C. M. Grabson.** A Study of the Antenna System. (*Radio News*, 3, p. 290, October, 1921.)

3217. **H. J. Round** [Radio Corporation of America]. Wireless Signalling Apparatus. (*U.S Patent* 1 95987, March 24th, 1921. Patent granted November 1st, 1921.)

The object of this invention is to provide means whereby the wavelength of a radio transmitter may be kept constant automatically. The antenna circuit and the closed oscillator circuit of the transmitter is combined with a small rotating field motor comprising two windings. One winding is connected in the closed circuit and the other winding in the antenna circuit or in any circuit whose period varies with that of the antenna. When the antenna is exactly in tune with the closed circuit there will be no rotating field produced by the two windings at right angles, but if the antenna increases its wavelength then the phase of the antenna current will tend to produce a rotating field in one direction whereas if the antenna

decreases its wavelength the rotating field will be in the other direction. The rotation of the shaft of the armature of the rotating field motor controls a variometer, a variable condenser, or other means for varying the period of the antenna. Thus when the antenna increases its wavelength the variometer decreases it until there is no longer any rotating field and *vice versa*, so that the wavelength of the antenna is kept practically constant. The system is intended for all types of sets such as a vacuum tube transmitter, an alternator, or an arc transmitter.

(2) ELEVATED AERIALS.

3218. **W. Reiss.** The Directional Effect of the Marconi Bent Antenna. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 294—299, April, 1921. *Science Abstracts*, 24B, p. 313, June 30th, 1921—Abstract. *Radioélectricité*, 2, p. 3D, July, 1921—Abstract.)

Experiments were made at Lärz in Mecklenburg with two identical bent aerials arranged back to back, *i.e.*, pointing in opposite directions. A valve transmitter was normally coupled to one of them, but by means of a rotating switch this aerial was disconnected and the other one connected in its stead in such a way that one aerial sent the signals and the other the spaces. The adjustments were made so that 1·5 km away broadside-on a continuous dash was heard. Observations at an end-on station 30 km away were then made at various wavelengths. Here also a continuous dash was received, although on inserting 15 ohms in one aerial and thus reducing its current 5 per cent. the signals could be distinguished. The conclusion is drawn that if there is any difference in the radiation in the two directions it does not exceed 3 per cent.

3219. **S. R. Winters.** A Condenser Type Wireless Antenna. (*Wireless Age*, 8, pp. 11—14, April; also p. 13, September, 1921. *Technical Review*, 9, p. 158, June 7th, 1921—Abstract. *Radioélectricité*, 2, p. 13D, August, 1921—Abstract.)

3220. **General Electric Company, U.S.A. [British Thomson-Houston Company].** Aerial Structures. (*British Patent* 152422, July 14th, 1919. Patent accepted October 14th, 1921.)

Relates to means for thawing sleet and snow on aerial wires by the application of A.C. heating current. The arrangements are particularly applicable to multiple aerials provided with several ground connections.

3221. **G. O. Squier.** Aerials. (*British Patent* 149917, August 3rd, 1920. Convention date August 3rd, 1919. Patent not yet accepted.)

Covers the use of trees, etc., to form wireless aerials.

3222. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Aerials. (*French Patent* 512209, January 13th, 1920. Published January 18th, 1921.)

For thawing sleet and ice from aerials, heating current is supplied thereto. An arrangement for doing this is described. (See also *British Patent* 152422, RADIO REVIEW Abstract No. 3220.)

3223. **A. Hund.** Formulæ for the Real and Effective Constants of a Horizontal Antenna. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 349—368, May, 1921. *Science Abstracts*, 24B, p. 364, Abstract No. 751, July 30th, 1921—Abstract.)

Develops the known formulæ for the effective inductance and capacity of an aerial. Only the simple case of a uniform horizontal antenna is considered.

3224. **G. W. Grauel.** An Ideal Cage Antenna and Counterpoise Ground. (*Wireless Age*, 8, pp. 25—26, July, 1921.)

3225. **G. J. Smith.** A Practical Cage Antenna. (*Wireless Age*, 8, pp. 26—27, July, 1921.)

3226. **G. F. Patrick.** Cage Aerials and Counterpoise Grounds. (*Wireless Age*, 8, p. 27, July, 1921.)

3227. **M. I. Pupin** and **E. H. Armstrong.** Multiple Antenna for Electrical Wave Transmission. (*U.S. Patent* 1388441, October 1st, 1915. Patent granted August 23rd, 1921.)

Multiple antenna for electrical wave transmission screened against the disturbing effects of electrical impulses of short duration. A receiving antenna, of such high resistance as to effectively screen the system against disturbing electromagnetic waves impressed upon the conductor, is employed in inductive relation with a low-resistance antenna which serves as a screen protecting the high-resistance antenna against electromagnetic pulses of short duration.

3228. **C. S. Franklin** [Radio Corporation of America]. Aerial System for Wireless Signalling. (*U.S. Patent* 1370735, September 30th, 1920. Patent granted March 8th, 1921.)
See corresponding *British Patent* 158927, RADIO REVIEW Abstract No. 3231.

(3) LOOP OR COIL AERIALS.

3229. **Société Française Radio-électrique.** (*British Patent* 146204, June 26th, 1920. Convention date November 3rd, 1916. Patent accepted July 28th, 1921. *British Patent* 148954, July 10th, 1920. Convention date November 3rd, 1916. Patent not yet accepted.)

These two specifications are identical, and deal with coil aerials for reception or transmission having their turns arranged in groups which may be connected in series or in parallel so as to tune the aerial to the wavelength employed. Capacities may be distributed along the turns of the aerial to reduce its wavelength. The transformation ratio of the first trans former of a high-frequency amplifier used with the apparatus may be similarly varied.

A form of aerial consisting of two horizontal plates is also described.

3230. **H. J. Round** and **G. M. Wright.** Aerials for Directive Signalling. (*British Patent* 149066, May 6th, 1919. Patent accepted August 6th, 1920.)

In order to avoid accurate tuning of the aerials of the Bellini-Tosi type the mutual inductance between the field and moving coils of the radiogoniometer is made as large as possible so that the loops themselves can be aperiodic. The necessary tuning is effected in the circuit of the moving coil of the radiogoniometer.

3231. **C. S. Franklin.** Uni-directional Wireless Reception. (*British Patent* 158927, September 24th, 1919. Patent accepted February 24th, 1921. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 226—227, September, 1921—Abstract.)

Two or more uni-directional receiving systems of the type described in *British Patents* 24098/1914 and 5783/1915 are spaced a fraction of a wavelength apart in the direction of the signals to be received. Oscillations in these two systems are combined by suitable phasing circuits with a common receiver. Each system is arranged to give a similar polar curve, and the resulting curve obtained by combining the two systems is better than either taken separately and gives almost zero reception in one direction (behind the station). Examples using four frame aerials in one plane, or four sets of two frame aerials at right angles in conjunction with radiogoniometers are mentioned as particularly suitable for duplex working as zero reception can be secured in six different directions.

3232. **C. S. Franklin, W. J. Picken,** and **J. G. Robb.** Aerials for Wireless Reception. (*British Patent* 159003, November 17th, 1919. Patent accepted February 17th, 1921.)

A modification of the arrangements described in RADIO REVIEW Abstract No. 3231, consisting of the addition of non-directive aerials to give more pronounced uni-directional results when combined with the directive aerials.

3233. **Gesellschaft für drahtlose Telegraphie.** Direction Finding Apparatus. (*British Patent* 147755, July 8th, 1920. Convention date June 3rd, 1918. Patent not yet accepted.)

An addition to *British Patent* 145629. One or both ends of the receiving frame aerial or amplifier may be earthed through condensers, or resistances, for increasing the energy absorbed by the receiving apparatus.

3234. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Aerials. (*French Patent* 509305, January 31st, 1920. Published November 6th, 1920.)

The receiving conductor for directive working consists of a coil having a large number of turns of insulated wire placed over copper sheets or coils having low impedance. The coil is mounted so as to be rotatable. (See also *British Patent* 127675, RADIO REVIEW Abstract No. 43, November, 1919.)

3235. **S. R. Winters.** The Resonance Wave-coil. (*Radio News*, 2, p. 766 and 822—823, May, 1921.)

A description of the mode of operation of long helix coils for receiving wireless signals, with illustrations of some apparatus used for this purpose at the U.S. Signal Corps Research Laboratory.

3236. Recent Developments in Loop Aerials. (*Radio News*, 2, p. 775, May, 1921.)

Describes various arrangements for screening receiving loop aerials including their use buried in the ground.

3237. **R. E. Lecault.** The Loop Aerial and its Application. (*Science and Invention*, 9, pp. 152—153, June, 1921.)

An illustrated description of some French loop aerial and amplifier installations.

3238. **H. K. Sandell** [Herbert S. Mills]. Wireless Transmitting System. (*U.S. Patent* 1391855, November 28th, 1919. Patent granted September 27th, 1921.)

A system employing a vacuum tube oscillator circuit having a loop antenna series connected in the input circuit of the oscillator and rotatably mounted and another loop antenna in series with the output circuit of the oscillator and arranged in proximity to the first-mentioned loop. In the circuit illustrated in the patent the oscillator is modulated by a telephone transmitter connected in the input circuit.

3239. **F. A. Kolster.** Apparatus for Transmitting Radiant Energy. (*U.S. Patent* 1394560, November 27th, 1916. Patent granted October 25th, 1921.)

A transmitter comprising a closed radiating circuit including a coil inductance and a capacity made up of large separated areas and serving with the inductance as radiating elements. The circuit is placed in oscillation by coupling a source of either damped or sustained energy to the system modulated in accordance with the signals.

3240. **W. H. F. Griffiths.** Frame Aerial Reception. (*Wireless World*, 9, pp. 195—197, June 25th, 1921.)

Some theoretical notes on reception with frame aerials.

3241. **J. O. Mauborgne** and **G. Hill.** Transmitting Aerials. (*British Patent* 165038, June 16th, 1921. Convention date June 16th, 1920. Patent not yet accepted.)

Relates to arrangements of helixes or " resonance coils " for transmission apparatus.

3242. **J. O. Mauborgne** and **G. Hill.** Resonance Wave-coil Antennæ. (*Science and Invention*, 9, pp, 348 and 385, August ; pp. 444 and 474, September, 1921.)

An illustrated description of the development of resonance wave-coil receiving antennæ with circuit diagrams of the amplifying apparatus used with them.

3243. **A. A. Campbell Swinton.** The Reception of Wireless Waves on a Shielded Frame Aerial. (*Philosophical Magazine*, 42, pp. 502—506, October, 1921. *Electrical Review*, 89, p. 356, September 9th, 1921—Abstract. *Engineering*, 112, p. 434, September 23rd, 1921—Abstract. *Electrician*, 87, p. 353, September 16th, 1921—Abstract. *English Mechanic*, 114, p. 120, September 30th, 1921—Abstract. *Chemical News*, 123, p. 189, October 7th, 1921—Abstract.)

See RADIO REVIEW, 2, pp. 545—547, October, 1921.

3244. **S. R. Winters.** A New Type of Condenser Antenna. (*Wireless Age*, 8, pp. 11—14, April, 1921.)

Describes experiments carried out at the Bureau of Standards on an aerial consisting of two parallel metallic plates arranged in either a horizontal or vertical plane. Photographs and circuit diagrams are given of the arrangement of the apparatus. Experimental measurements of the resistance and directional properties (polar curves) are set out and it is concluded that this type of antenna should be particularly promising both for the reception and transmission of short waves.

3245. **H. de A. Donisthorpe.** An Efficient Frame Aerial System. (*Model Engineer*, 45, pp. 335—336, October 28th, 1921.)

Gives constructional details.

(4), (5) AND (6) BURIED AERIALS ; AIRCRAFT AND SUBMARINE AERIALS.

3246. **Peperkorn.** Earth Antennæ and their Use during the War in German East Africa. *Telegraphen- und Fernsprech-Technik*, 10, pp. 36—41, April; pp. 55—60, May, 1921. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 300—305, April, 1921—Abstract. *Elektrotechnische Zeitschrift*, 42, pp. 440—441, April 28th, 1921—Abstract. *Radioélectricité*, 1, p. 139D, June; and p. 19D, September, 1921—Abstract.)

An interesting account of the successful use of long horizontal wires suspended a few feet above the ground. When oscillating at their fundamental there was little directive effect, but if made longer so that the signal wave was a harmonic of the aerial wire the directive action was very pronounced and enabled interference from other stations to be avoided.

To their surprise these so-called earth aerials gave better signals from Europe than were obtained on the 100-metre umbrella antenna at Dar-es-salam. The possibility of rapid construction and removal and the invisibility of this type of aerial are great advantages in time of war. Many details of experiments with various arrangements of the wires are given in the paper. (See also RADIO REVIEW, 2, p. 281, June, 1921.)

3247. **Signal Gesellschaft m.b.H.** Subaqueous Telegraphy. (*French Patent* 510605, January 9th, 1915. Published December 18th, 1920.)

Ships and stations located near the water are provided with submerged antennæ and such a frequency is employed that the capacity of the water is not more than its resistance. See also *British Patent* 398/1915.

3248. **G. W. O. Howe.** Earth Aerials. (*Radio Review*, 2, pp. 281—282, June, 1921.)

3249. **E. C. Hanson.** Underground and Submarine Antenna. (*U.S. Patent* 1388336, February 25th, 1919. Patent granted August 23rd, 1921.)

Underground and submarine antenna wherein the antennæ are formed by a pair of extended inductances connected to radio signalling apparatus. The inductances are buried horizontally in the earth and have their ends electrically free.

3250. **E. R. Clarke.** Wireless Systems for Aircraft. (*British Patent* 150747, August 16th, 1916. Patent accepted February 4th, 1920. Published October 7th, 1920.)

Means for directing aircraft by wireless telegraphy comprise a single receiving coil aerial of any suitable number of turns mounted on the aircraft so that its effective plane is normally perpendicular to the fore and aft line of the machine but can be rotated through a small angle on each side of this position, so as to obtain zero effect from the incoming waves. Alternatively the centre parts of the loop or coil may be fixed and the two end sections hinged to turn in opposite directions.

3251. **L. A. McDougald** and **J. M. Poyntz.** Aerials for Aircraft. (*British Patent* 151115, July 2nd, 1919. Patent accepted September 23rd, 1920.)

Relates to open-ended aerials attached to the fuselage of the machine.

3252. **E. F. Huth.** Aerials for Aircraft. (*British Patent* 148315, July 9th, 1920. Convention date July 1st, 1915. Patent accepted October 10th, 1921.)

Relates to reels for coiling up the aerial wire on aircraft.

3253. **E. F. Huth.** Aerial Winches. (*British Patent* 148318, July 9th, 1920. Convention date January 16th, 1918. Patent not yet accepted.)

Relates to means for winding up the aerial on aircraft by means of power derived from an air-driven propeller or by other similar means.

3254. **E. F. Huth.** Reels or Winches. (*British Patent* 148319, July 9th, 1920. Convention date May 16th, 1918. Patent accepted October 10th, 1921.)

Relates to a reel for an aircraft aerial having an electric motor for winding up the wire.

3255. **P. R. Coursey.** The Submarine's Wireless. (*Wireless World*, 8, pp. 603—605, November 27th, 1920. *Electrical World*, 77, p. 441, February 19th, 1920—Abstract.)

Describes various forms of aerials used for underwater communication.

3256. **B. Rosenbaum** [E. F. Huth Gesellschaft]. Aerial Construction. (*British Patent* 149194, July 12th, 1920. Convention date December 8th, 1916. Patent not yet accepted.)

Submersible boats are fitted with horizontal antennæ a small height above the deck to enable them to maintain radio communication whether submerged or on the surface. The shore stations may be provided with similar antennæ for communication with these vessels.

3257. **J. H. Rogers.** Radio Signalling System. (*U.S. Patent* 1395454, March 9th, 1920. Patent granted November 1st, 1921.)

This patent shows an antenna for a submarine vessel having a metallic hull comprising conductors extending longitudinally within and entirely enclosed by the hull and electrically connected at their ends to the metallic walls of the hull. The radio signalling apparatus is inductively coupled to this antenna system. A modification of the system shows a loop antenna contained entirely within the metallic hull of the submarine.

(7) SPECIAL D.F. AERIALS.

3258. **J. O. Mauborgne** and **G. Hill.** Receiving Aerials. (*British Patent* 163709, May 24th, 1921. Convention date May 24th, 1920. Patent not yet accepted.)

Relates to the use of a long helix (" resonance-wave coils ") for receiving wireless signals, and deals with its directional properties.

3259. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Receiving System. (*French Patent* 512838, March 31st, 1920. Published February 1st, 1921.)

The receiving system employs a loop aerial, whereby two separate currents are obtained, one from the action of the aerial as a directive-electromagnetic loop, and the other from the action of the aerial as an earthed symmetrical non-directional aerial. These currents are produced in separate couplings and are impressed upon intermediate phase modifying circuits. For further particulars see *British Patent* 142074, in the name of E. F. W. Alexanderson.

3260. **Gesellschaft für drahtlose Telegraphie.** Wireless D.F. Apparatus. (*British Patent* 167490, August 4th, 1921. Convention date August 6th, 1920. Patent not yet accepted.)

The polar diagram of a wireless D.F. installation may be varied by changing the constants of the antenna system which comprises a combination of directional and non-directional antenna.

(8) AERIAL INSULATORS, ETC.

3261. **A. Renaudin.** High Tension Suspension Insulators. (*British Patent* 159198, February 18th, 1921. Convention date February 28th, 1920. Patent not yet accepted.)

3262. **C. T. Wilkinson.** Wireless Aerials. (*British Patent* 151063, June 12th, 1919. Patent accepted September 13th, 1920.)

Relates to a means of keeping aerial wires taut by counterweights.

3263. **G. V. Tuiss.** Strain Insulators. (*British Patent* 158689, November 10th, 1919. Patent accepted February 10th, 1921.)

3264. **E. H. Fritz** and **G. I. Gilchrest.** Modern Production of Suspension Insulators. (*Journal of the American Institute of Electrical Engineers*, 40, pp. 470—479, June, 1921.)

An illustrated article describing the processes.

3265. **G. Castelnuovo-Tedesco.** A New High-voltage Suspension Insulator. (*L'Elettrotecnica*, 7, pp. 366—368, July 15th, 1920. *Electrical World*, 77, p. 498, 1921—Abstract. *Elektrotechnische Zeitschrift*, 42, p. 379, April 14th, 1921—Abstract.)

A solid porcelain rod with metal clamps at the top and bottom without cement. The upper clamp carries a metal umbrella which can arc across to the bottom clamp without damaging the porcelain.

3266. **Brown, Boveri & Cie.** Bakelite. (*B.B.C. Mitteilungen*, 7, p. 229, 1920. *Elektrotechnische Zeitschrift*, 42, pp. 381—382, April 14th, 1921—Abstract.)

An illustrated description of the various modifications and applications of bakelite in the manufacture of various types of insulators.

(9) EARTHING SYSTEMS.

3267. **R. Goldschmidt.** Earthing Systems. (*British Patent* 148786, July 10th, 1920. Convention date November 8th, 1917. Patent not yet accepted. Also *British Patent* 148788, July 10th, 1920. Convention date March 22nd, 1917. Patent not yet accepted.)

The earth connections of radio stations may be arranged in the form of radial insulated conductors each leading to star-like arrangements of earth wires of comparatively short length. Condensers may be inserted in the radial insulated leads.

3268. **A. F. Wallis.** Ground System at Arlington Station. (*Radio News*, 2, p. 354, December, 1920.)

A short note about the arrangement with photograph.

3269. **L. Lichtenstein.** Earth Currents in Theory and Practice. (*Elektrotechnische Zeitschrift*, 42, pp. 841—846, August 4th, 1921.)

A mathematical investigation of the effective resistance of earthing systems.

(11) MASTS AND TOWERS.

3270. **C. F. Elwell.** Wooden Masts for Radiotelegraphy. (*L'Électricité pour Tous*, 3, p. 145, May 31st, 1921.)

3271. **J. Harrison.** Masts. (*British Patent* 160027, December 31st, 1919. Patent accepted March 17th, 1921.)

A telescopic mast for wireless and other purposes.

3272. **R. St. George-Moore** and **G. S. Whitmore.** Supporting Wireless Aerials. (*British Patent* 158353, November 3rd, 1919. Patent accepted February 3rd, 1921.)

Relates to methods of supporting wireless antennæ so that the resultant stress upon the mast shall be vertical.

3273. **S. P. Wing.** Wind Pressures and the Design of Radio and High Transmission Towers. (*Electrician*, 87, pp. 6—10, July 1st, 1921.)

In this paper the author deals with the problem of wind pressures at varying heights above ground and their consideration in the design of masts and towers. It is pointed out that the literature on the subject is very meagre and in the erection of well-known constructions the assumptions for wind pressures have been greatly at variance. The author gives the results of a large number of observations and readings taken at Ballybunion, Co. Kerry, Ireland, and from these draws the conclusions that where the elevation is close to sea level the wind velocity increases considerably with the increase in elevation above ground and has not reached the limit of increase at 500 feet; that the increase is limited by the "gradient wind" and will probably not exceed 15 per cent. of that reached at 500 feet; that the extreme variation in wind velocity at 750 feet is between 140 and 170 per cent. of the ground velocity; and that an equation supplied by the author gives an approximation of actual pressures within 15 per cent. for high pressures.

3274. **S. Moehl.** Aerial Masts. (*British Patent* 164100, February 27th, 1920. Patent accepted May 27th, 1921.)

An aerial mast suitable for wireless telegraphy has a self-supporting tower at the top of which a slender column is attached by means of a universal joint and anchored by means of stays attached to the ground.

3275. **F. Omori.** Measurement of the Vibration of the 660-foot Wireless Telegraph Station at Haranomachi. (*Engineering*, 112, pp. 196—199, July 29th, 1921.)

3276. Latticed Wireless Towers for Amateur Stations. (*Wireless Age*, 8, pp. 32—33, September, 1921. *Radio News*, 3, p. 193, September, 1921.)

3277. **A. Heinemeyer.** Formulæ for the Rigidity of Lattice Masts. (*Elektrotechnische Zeitschrift*, 42, pp. 825—827, July 28th, 1921.)

(L). Radio Wave Transmission.

(2) TRANSMISSION TESTS AND MEASUREMENTS.

3078. **M. S. Kinter.** The Variation of Radio Signals. (*Telegraph and Telephone Age*, 39, p. 277, June 16th, 1921.)

An abstract of a paper read before the Institute of Radio Engineers giving the results of experiments carried out by the International Radio Telegraph Company on the variation of transatlantic signal strengths. These variations were compared with the corresponding variations of atmospheric disturbances, and the effects of sunrise and sunset were also investigated.

3079. **L. W. Austin.** Measurement of the Signals received in Washington from the Lafayette Station. (*Science Abstracts*, 24B, p. 415, August 31st, 1921—Abstract.)

See RADIO REVIEW, 2, pp. 301—303, June, 1921.

3080. **A. H. Lynch.** S.S. *Aeolos* Works 3,013 Miles with 2 kW Arc Set. (*Science and Invention*, 9, p. 151, June, 1921.)

An illustrated description of the installation.

3081. **S. R. Winters.** Fading of Signals. (*Radio News*, 2, p. 529, February, 1921.)

An outline of the scheme developed by the Bureau of Standards in conjunction with the American Radio Relay League for the investigation of transmission phenomena on short wavelengths. (See also RADIO REVIEW Abstract No. 2066, July, 1921.)

3082. Radio Telephony over 4,340 Kilometres. (*Telefunken Zeitung*, 4, pp. 39—43, May and June, 1921. *Telegraphen- und Fernsprech-Technik*, 10, p. 94, July, 1921—Abstract.)

It is reported that telephonic messages from Nauen were received by the Argentine liner *Bahia Blanca* at a distance of 4,340 km, the antenna power being 130 kilowatts ; Königswusterhausen using 10 kilowatts was heard up to 3,500 km.

3083. Reception Experiments in Argentine. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 366—368, May, 1921. *Science Abstracts*, 24B, p. 364, Abstract No. 752, July 30th, 1921—Abstract.)

A report of tests made by the Telefunken Company preparatory to the establishment of wireless communication between Germany and Argentine. Reception tests were made at several widely separated stations. Apparently frame aerials of large size, in one case 28 × 68 metres, were employed. Records are given for six months, the strengths of the signals from Nauen and of the atmospherics being given in parallel ohms shunted across the telephone receivers. In only one of the six months could Nauen be read on more than half the days of the month. The relative strengths of the signals and atmospherics can be judged from the parallel ohms which varied from 2·83 for atmospherics and 4·74 for signals in July (Nauen read on twenty-eight days) to 1·45 for atmospherics and 10·5 for signals in November (Nauen read on ten days). The tests are to be continued with the most modern apparatus.

3084. **J. H. Dellinger** and **L. E. Whittemore.** Radio Signal Fading Phenomena. (*Journal of the Washington Academy of Science*, 11, pp. 245—259, June 4th, 1921. *Science Abstracts*, 24B, p. 460, Abstract No. 924, September 30th, 1921—Abstract. *Physical Review*, 18, pp. 148—149, August, 1921—Abstract.)

Paper read before the Philosophical Society of Washington, January 29th, 1921, and before the American Physical Society, April, 1921. The mechanism of the fading of signals is discussed from the point of view of its variation with distance, place and wavelength, sunrise and sunset, and similar effects on the phenomena and on atmospherics are also considered. It is concluded that the causes or sources of fading and of atmospherics are in the atmosphere between the earth's surface and the Heaviside surface, but that the origin of these causes is either from below the ground or from outside the earth's atmosphere. The grid variations in signal strength experienced at night are attributed to irregularities in the surface of the Heaviside layer.

3085. **H. de Bellescize.** Resonance and the Continuity of Radio Communications. (*Radio-électricité*, 2, pp. 25—29, July ; pp. 69—76, August, 1921.)

A critical discussion of the influence of atmospherics on radio communications and in particular of the importance of the ratio of the field strength due to atmospherics and signals. Formulæ are given for determining this ratio under different conditions. The importance of resonance and particularly of low-frequency resonance is emphasised.

3086. **F. Addey.** Eclipse of the Sun, April 8th, 1921—Effects Produced at Wireless Stations, (*Radio Review*, 2, pp. 226—227, May, 1921. *Telegraph and Telephone Age*, 39, p. 390. September 1st, 1921—Abstract.)

3087. **R. C. Gray.** Wireless Telegraphy in Western Australia. (*Radio Review*, 2, pp. 507—508, October, 1921.)

3088. The Fading of Radio Signals. (*Experimental Science*, 1, p. 181, August-September, 1921.)

The suggestion is made that some of the fading phenomena may be due to changes in the wavelength to which the transmitter or receiver is tuned.

3089. An International Series of Radio Audibility and Direction Measurements. (*Physical Review*, 18, pp. 150—152, August, 1921.)

An abstract of paper read before the American Physical Society on similar lines referred to in RADIO REVIEW Abstract No. 1070, November, 1920.)

(M.) Atmospherics, including Anti-atmospheric Devices.

3290. **G. M. Wright** [Radio Corporation of America]. Wireless Telegraph Receiver. (*U.S. Patent* 1394600, June 8th, 1916. Patent granted October 25th, 1921.)

A receiver having a circuit for the reduction of noises due to atmospherics. The natural resistance of the antenna may be made of such a value as to damp the atmospherics while the effective resistance is reduced by the interaction of the incoming and outgoing circuits of a vacuum tube connected between the antenna system and the receiver. The filament of the vacuum tube is heated so slightly as to produce only very small magnification and to all practical degree no magnification of the signals, but sufficient to neutralise the antenna resistance for the weaker amplitudes of signals and yet render effective the resistance for the larger amplitudes of atmospherics.

(N.) Interference and Interference Prevention, including Secrecy Methods of Signalling.

3291. **R. H. Wilson** and **J. P. Schafer** [Western Electric Company.] Secret Signalling. (*U.S. Patent* 1395378, September 29th, 1919. Patent granted November 1st, 1921.)

This patent shows a radiotelephone secret signalling system. The transmitter comprises two branch circuits and separate modulators coupled thereto. The microphone circuit is coupled to filters which transmit freely only a limited range of the essential voice frequencies. For example, one filter may transmit frequencies between 500 and 900 while the other filter will transmit frequencies between 900 and about 1,500. Separate carrier wave frequencies may be employed modulated in accordance with the frequencies transmitted through the filters. At the receiving station branch circuits are employed to combine the component frequencies forming the signal wave. An outsider in attempting to pick up the conversation would tune his receiving set to the frequency of one or the other of the transmitted carrier waves but would obtain only unintelligible sounds from either wave alone.

(O.) Duplex and Multiplex Radio Communication.

3292. **A. N. Goldsmith** and **J. Weinberger** [General Electric Company]. Radio Receiving System. (*U.S. Patent* 1396571, September 13th, 1918. Patent granted November 8th, 1921.)

The object of this invention is to provide a receiving system which is adapted to be used in close proximity to a transmitting system and which is capable of receiving signals from a distant station at the same time that signals are being sent from the transmitting station.

(P.) High-frequency Circuits and Measurements.

3293. **E. A. Bayles** and **H. Higham** [assigned one-third to Ernest Richard Royston]. Electrical Condenser. (*U.S. Patent* 1393602, December 22nd, 1919. Patent granted October 11th, 1921.)

A condenser comprising a plurality of condenser units, each unit made up of a series of spaced longitudinally-aligned tubular condensers electrically connected and supported in removable racks within an oil container.

3294. **W. C. Brinton, Jun.** [Philbrin Corporation]. Electrical Condenser. (*U.S. Patent* 1393077, October 8th, 1918. Patent granted October 11th, 1921.)

A condenser comprising layers of conducting material and layers of fibrous dielectric material of different degrees of hardness and compressibility, the harder and less compressible layers being of greater weight than the softer and more compressible layers. The entire condenser is enclosed in a tight-gripping casing compressing the layers in inter-relation.

3295. **W. Dubilier.** Electrical Condenser. (*U.S. Patent* 1391672, August 1st, 1918. Patent granted September 27th, 1921.)

A condenser constructed of rectangular plates having one dimension substantially greater than the other and interleaved with larger rectangular insulating sheets of greater length than width. The novelty in this condenser lies in the construction of the stack. The side edge portions of the longer dimension of the condenser plates project alternately beyond the two

longer sides of the dielectric sheets, the similarly projecting edge portions of the plates being connected together throughout their whole length to constitute the terminals for the condenser. The terminals are thus constructed to provide the shortest mean heat conduction path and the path of lowest mean resistance to the exterior of the condenser.

3296. **W. Dubilier** [Dubilier Condenser Co., Inc.]. Antenna Shortening Device. (*U.S. Patent* 1391673, March 7th, 1919. Patent granted September 27th, 1921.)

A series antenna condenser comprising a plurality of condenser sections connected in series and tapped to different terminal posts arranged on a casing containing the condenser sections. A switch arm is provided movable over the terminal posts to connect in circuit the respective condenser sections in series with an antenna system to shorten the wavelength to the desired value. A short-circuiting contact is provided whereby the series condenser may be entirely cut out of the antenna circuit.

3297. **C. F.** and **W. H. Smith.** Electric Condenser. (*U.S. Patent* 1395931, May 17th, 1920. Patent granted November 1st, 1921.)

An electric condenser unit is shown in this patent comprising a base or body of thin fibre board and a wrapping of dielectric and metallic foil encircling the fibre board. The sheets of metal foil are smaller in size than the sheets of dielectric and the stack is folded around the fibre board and the leads brought out to eyelet terminals on the ends of the board. A number of units may be associated in parallel by building up a structure with bolts passing through the eyelet terminals.

3298. **P. Thomas** [Westinghouse Electric and Manufacturing Company]. Condenser. (*U.S. Patent* 1396897, October 8th, 1917. Patent granted November 15th, 1921.)

This patent shows a construction of condenser having means for filling the space which remains at the edges of the conducting foils in condensers constructed in the usual manner. A U-shaped strip of dielectric material is cut to closely fit around the margin of a conducting foil, the strip being substantially of the same thickness. The conducting sheets assembled with the U-shaped strips are stacked with intermediate sheets with one side of the conducting sheet extending to form the terminals of the condenser.

3299. **Albert Pruessman** [Western Electric Company]. Condenser and Method of Making the Same. (*U.S. Patent* Reissue No. 15241, June 14th, 1920. Patent granted November 29th, 1921.)

This patent relates to a method of treating a condenser which is impregnated in the presence of heat which consists in applying pressure to the impregnated condenser as it cools and then removing the pressure, reheating the condenser to a temperature of not less than 120° F. for a period of not less than three hours without pressure applied thereto.

3300. **W. Dubilier.** Variable Condenser. (*U.S. Patent* 1396030, July 25th, 1917. Patent granted November 8th, 1921.)

A variable condenser is shown in this patent comprising a number of fixed condenser units connected to contacts, a switch for cutting in the units, and a variable condenser having a maximum capacity substantially equal to the common difference between the capacities of the fixed condenser units. Intermediate capacities between the fixed capacities are thereby obtained by manipulating the variable condenser while the errors due to changes in the variable condenser are minimised.

(R.) Radio Direction Finding.

3301. **L. M. Knoll** [Thomas Appleby]. Radio System. (*U.S. Patent* 1394026, April 2nd, 1920. Patent granted October 18th, 1921.)

A receiving system for the location of the actual direction of a transmitting station as an improvement over systems which merely indicate the course of the signals but do not differentiate between the true and converse directions. The system comprises the combination of an antenna circuit with a pair of rectangular loop collectors rotatably mounted and adapted to have their mutual coupling varied.

3302. **James Erskine-Murray** and **James Robinson.** Wireless Receiving and Transmitting Apparatus. (*U.S. Patent* 1398848, March 30th, 1920. Patent granted November 29th, 1921.)

This patent shows a radio transmitting and receiving system wherein a receiving station

determines its bearing relatively to the transmitting station. The transmitting apparatus employs a plurality of antennæ arranged in different directions, while the receiving station employs an antenna having branch circuits to ground which are alternately connected in the antenna circuit. Two identical coils are included in the branch circuits and arranged at an angle with each other. An adjustable receiving inductance is coupled with the two circuits and adjusted for comparison of the received signals which permits a bearing to be obtained on the distant transmitting station on minimum signal.

3303. **R. L. Williams** [Submarine Signal Company]. Device for Estimating Distances. (*U.S. Patent* 1396491, June 24th, 1919. Patent granted November 8th, 1921.)

This patent shows a combination radio system and submarine sound signal system wherein a radio transmitter is operated to give a single signal simultaneously with the operation of a submarine sound signal. The operator at the receiving station gets the single instantaneous radio signal and later hears the first blow of the submarine signal and by measuring the time between the receipt of the radio signal and the first blow of the submarine signal can calculate the distance from the transmitting station.

(S.) Distance Control by Wireless.

3304. **J. H. Hammond, Jun.** System of Radiodynamic Control. (*U.S. Patent* 1399254, June 30th, 1917. Patent granted December 6th, 1921.)

This patent shows a radio transmitter control circuit for use in a system of radiodynamic control for torpedoes and the like. The transmitter includes two sets A and B, the set A being intended to transmit different wavelengths through any desired variable range to disturb the enemy. The set B is provided with a plurality of control circuits, whereby the frequency transmitted may be changed over a series of wavelengths to control the distant object.

3305. **E. L. Chaffee.** Means for Changing the Intensity of Signals in Radiodynamic Receiving Systems. (*U.S. Patent* 1399251, July 31st, 1917. Patent granted December 6th, 1921.)

This patent shows a circuit for the reduction of the intensity of strong signals in radiodynamic control work without reducing the intensity of weak signals. The object of the invention is to reduce interference in radiodynamic control circuits from near-by transmitters and from static.

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2. Books.

WIRELESS TELEGRAPHY. By B. Leggett. (London: *Chapman and Hall, Ltd.* 1921. $8\frac{1}{2}'' \times 5\frac{1}{4}''$. Pp. xv + 485. With 230 figures. Price 30*s*. net.)

Although the title on the outer cover is merely "Wireless Telegraphy," one finds, on opening the book, the sub-title "With Special Reference to the Quenched-spark System." It would have been more honest to have entitled the book "The Quenched-spark System of Wireless Telegraphy," since it is confined almost entirely to descriptions of that system. Among the many amazing things to be found in this book is the following, which we presume is the author's apology for having written it. "Whilst at the present day a very large number of books dealing with wireless telegraphy are published, yet with very few exceptions *these are not written by actual wireless engineers*. This leads to two types of books, either those written by the pure scientist, which are highly mathematical and whilst of great theoretical interest are relatively unimportant in practical work; or to a more popular class of book which deals with actual wireless apparatus, *but whose matter is largely obtained second-hand from other books such as the admirable treatise by Fleming*, which chiefly deals with the Marconi system, the excellent practical handbook on the same system by Hawkhead; or the smaller but perhaps more general and useful book by Eccles." The italics are ours. It would be interesting to have the author's definition of a wireless engineer. It would apparently exclude pure

scientists and such writers of popular books as Fleming, Hawkhead and Eccles; but we have a shrewd suspicion that it would include Mr. B. Leggett.

The book opens with a historical summary in which the author never misses any opportunity of attacking the Marconi Company or of drawing comparisons between the super-excellence of the Telefunken Company and the marked inferiority of all others. It is perhaps fortunate, however, that it is so overdone that any ordinary reader will see through it and smilingly discount the statements made. Having ourselves a great admiration for the work done by the Telefunken Company we cannot but feel that the author has done them a disservice in publishing such a book.

The book contains a large number of excellent diagrams and photographs, the type, paper and binding are all very good, and the apparatus is clearly described in the manner of a high-class descriptive catalogue. Very little numerical technical data is given, however, and what little theory is attempted only makes one thankful that there is no more. The explanation of this is to be found on p. 30, where we read that "The large number of technical engineers who visited this station and were often given demonstrations of the new apparatus by the present writer. . . . The technical side of the wireless section was in charge of Mr. H. A. Machen. . . ." It is a pity that a similar distribution of duties was not adopted in writing the book.

We can only refer to a few of the points which struck us on looking through the book. In the historical introduction Poulsen becomes a Swede, Sir Henry Babington Smith becomes Postmaster-General, and the Nobel Prize, which was awarded to Wilhelm Wien in 1911, is taken away from him and awarded to Max Wien, presumably as a reward for the discovery of the quenched gap. We are told that in June, 1912, "Wireless communication was established by the Australian Telefunken licensees across Australia between Perth and Freemantle" [the distance between these places is about 8 miles]. Throughout the book the reader is impressed with the fact that the number of kilowatts by which the Telefunken Company designate a station is the "*energy radiated from the aerial, which is 50 to 75 per cent. of the prime energy.*" From the frequency of this and similar misstatements one is forced to the conclusion that the author is ignorant of the fundamental principles of the subject. On p. 12 we read that "It must, however, be borne in mind that many of these other systems employ Quenched-Spark Gaps little different to the *original* Telefunken Gap; for example, the Lepel system employs a spark-gap whose chief difference is the *replacement* of the mica discs between the spark-gap plates by paper discs." We wonder whether the author knows which was the original and which the replacement.

The author follows the usual German plan of referring to the plain aerial as the Marconi Aerial and comparing it with the Coupled or Braun Aerial. When the aerial is tapped directly on to the inductance of the oscillatory circuit, *i.e.*, with auto-transformer coupling, the author calls it electrostatic coupling. Although the purely descriptive diagrams are good, the author gets into deep water as soon as he leaves the Telefunken pamphlets and essays to explain resonance phenomena in his own words; for example, both the ordinates and abscissæ of the lower curve in Fig. 15 appear to have got hopelessly muddled.

After all that has gone before one reads with surprise on p. 72 that "The most important difference between typical Quenched-spark and Marconi Commercial stations is that of the A.C. source which in the first case is a motor generator and in the second a rotary converter." If this is so, what is all the fuss about?

In a chapter on detectors, we read "Magnetic detectors :—The chief type of such detectors is that of the Marconi Company which whilst known as the 'Marconi' Magnetic detector was first evolved by Rutherford in 1896." This is typical of the tone which pervades the whole book.

On p. 113 occurs the following choice paragraph (the italics are ours): "Many, such as carborundum and steel, work best when an external E.M.F. is applied by means of *dry* cells. This *obviously* causes the contact to be heated until maximum variation of generated E.M.F. is obtained. The *maximum temperature* is easily found practically by variation of a resistance or potentiometer."

The cover bears the inscription "The D. U. Technical Series"; on opening the book we are informed that D. U. stands for directly useful, but we regret to have to say that the volume under review suggests another interpretation, the second word of which is Unreliable.

G. W. O. H.

LA THÉORIE ET LA PRATIQUE DES RADIOCOMMUNICATIONS, Vol II.—La Propagation des Ondes Électromagnétiques à la Surface de la Terre. By Léon Bouthillon. (Paris: *Librairie Delagrave*. 1921. Pp. xv + 340. With 133 figures. 10″ × 6½″. Price 20 fr.)

This forms the second volume of a comprehensive work covering the whole range of radiotelegraphy and telephony. The publishers announce that six further volumes are in preparation, viz., III. Oscillations électriques; IV. L'antenne—La direction des ondes; V. Les méthodes de transmission; VI. Les méthodes de réception; VII. Les divers genres de radiocommunications; VIII. Formulaire du radiotélégraphiste. When M. Bouthillon has completed this ambitious programme he will have provided us with the most comprehensive work on the subject in existence. The first volume which was called an introduction to the subject was reviewed in the RADIO REVIEW of May, 1920. The preface to the second volume contains not only a general review of the subject dealt with in the volume but also an essay on the rival claims of theory and practice, and of the relation of the mathematician to both. The book is divided into two parts, the first dealing with the observed facts and the second and larger part with what are modestly called "tentatives d'explications." The first part is further subdivided into five chapters entitled respectively, I. Propagation over short distances; II. Over long distances; III. Effect of geographical configuration; IV. Meteorological effects; V. Parasitic signals. The second or theoretical part is subdivided into three chapters, viz., VI. Effect of the soil; VII. Effect of the earth's curvature; and VIII. The *rôle* of the atmosphere.

The first part consists of a general review of the experiments made in transmission from the early experiments of Marconi, Tissot, Duddell and Taylor and Admiral Jackson down to the recent work of de Groot, Vallauri and Eckersley, and the cruise of the *Aldebaran*. It consists largely of translations from the original together with reproductions of the original curves and diagrams. The second part is similarly a review of the work done by various workers on the theoretical and more purely physical side. It deals fully with the work of Poincaré, Sommerfeld, Hoerschelmann, Zenneck, Macdonald, Nicholson and Watson. The meteorological theories of Arrhenius, Störmer, Eccles and others are explained and discussed.

One must not turn to this volume expecting to find new theories or new methods of presentation. It consists almost entirely of a review of the literature of the subject. Papers which are scattered throughout the Proceedings of various learned societies are here brought together, summarised and arranged in their proper places in the development of the subject. The authors' names are always given in large type together with references so that one can consult the original papers if one desires.

In writing the well-known Austin-Cohen formula we notice that the author, as in the preceding volume, always separates the effective resistance of the aerial into two parts, viz., that associated with dissipation of power and that associated with radiation of power, the former is called the resistance and the latter the *radiance*. The total effective resistance, as usually understood, is written $R + \omega^2S$. Although the radiance ω^2S is not a real resistance, the same might be said of R; when multiplied by the square of the current at the foot of the antenna, the former gives the sum total of the power dissipated in various ways, including dielectric hysteresis, whilst the latter gives the power radiated. As written by Bouthillon the expression suggests that R is independent of the frequency, which is in many cases far from true, although its variations are small and irregular compared with those of the radiance. It is, however, undoubtedly advantageous to separate in this way two components which are so fundamentally different in their nature.

From what we have said above as to the character of the volume it is obvious that it will prove an indispensable work of reference to all serious students of radio communication. In conjunction with the first volume it would form a very suitable text-book for a post-graduate course of study on the nature of Hertzian waves and their application to radio communication.

G. W. O. H.

THE ELECTRICIAN'S HANDY-BOOK. By T. O'Conor Sloane. (London: *Hodder and Stoughton*. Fifth Edition. 1921. Pp. 823. 6½″ × 5″. With 600 illustrations. Price 27*s*. 6*d*. net.)

This volume is a comprehensive reference book suitable either for the student or the electrical engineer. It contains forty-six chapters, each being devoted to a separate branch of the subject, commencing with an introduction on elementary mathematics as applied to electrical

calculations. Subsequent chapters deal with electrical units, the electric current, magnetism, etc., following the general sequence found in most electrical engineering text-books.

The formidable task of keeping a book of this type quite up to date probably explains the omission of references to the most modern practice or apparatus in some cases, such, for instance, as in the section devoted to wireless telegraphy in which no mention is made of the thermionic valve. Doubtless future editions will rectify these small defects.

A very comprehensive index adds considerably to the general utility of the volume, and facilitates reference to unusual items.

P. R. C.

Books Received.

THE "PRACTICAL ENGINEER" ELECTRICAL POCKET BOOK AND DIARY, 1922. (London: *The Technical Publishing Co., Ltd.* 1922. Pp. cxxx + 610. $5\frac{1}{2}'' \times 3\frac{1}{2}''$. Price 2*s*. net.)

HANDBUCH DER DRAHTLOSEN TELEGRAPHIE UND TELEPHONY. By E. Nesper. (Berlin: *Julius Springer.* 1921. Two vols. Pp. l + 708, and pp. 545 respectively. $9\frac{3}{4}'' \times 6\frac{1}{2}''$. With 1,321 illustrations. (Price not stated.)

CONTINUOUS WAVE WIRELESS TELEGRAPHY. By B. E. G. Mittell. (London: *Sir Isaac Pitman & Sons, Ltd.* 1922. Pp. xv + 114. $6\frac{1}{4}'' \times 4''$. With 58 illustrations. Price 2*s*. 6*d*. net.)

Correspondence.

NOTES ON A DIRECT-READING RADIO DIRECTION FINDER.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—In the January issue of the RADIO REVIEW Mr. Artom, in an article under the above title, describes a direct-reading radiogoniometer, the pointer of which would materially indicate the direction of a sending station. This apparatus would certainly realise a very important progress upon the Bellini-Tosi radiogoniometer, were it possible to make it work.

As a matter of fact, from the point of view of the conception of the apparatus, the presence of a detector in each of the two circuits produces an ambiguity as to the direction of a station, as a station making an angle $+\alpha$ with one of the fixed aerials would give exactly the same bearing as a station making an angle $-\alpha$ with the same aerial. One would always be uncertain whether the direction indicated by the apparatus would be the real one or the symmetrical of this in respect of each aerial.

From the point of view of the practical construction of the apparatus it appears impossible to obtain sensitiveness and exactitude sufficient for practical purposes.

E. BELLINI.

Enghien-les-Bains,
January 21st, 1922.

The above letter has been submitted to Mr. Artom who has replied as follows:—

SIR,—Mr. Bellini's letter is a great violation to my rights.

Professor Artom's Italian (April 11th, 1907), French and German Patents, the public act of April 5th, 1912, the judgments of County Court and Cassation Courts of Turin, establish that the priority of the invention of the Radiogoniometer belongs to Professor Artom and not to Mr. Bellini, who has been an employee of the concessionaires of my patents.

I do not acknowledge to Mr. Bellini either the authority, or the necessary impartiality, to judge my scientific studies, and I do not take notice of his technical observations, which are absolutely without any foundation.

ALEXANDRE ARTOM.

Turin,
January 30th, 1922.

TRIODE CHARACTERISTICS WITH HIGH GRID POTENTIAL.

To the Editor of the "Radio Review."

Sir,—Mr. Appleton's Fig. 1 in his letter in the January number is quite irrelevant. The only changes of slope that we are discussing are those in which (as he said in his first letter) "the grid potential approaches that of the anode." Nor is his exposition of electrostatic principles relevant, for my argument can be expressed in the manner he desires in terms of potentials and fields.

I do not assume "that the electrons (always) tend markedly to follow the lines of force." But I do assume that their paths, whatever they may be, are determined by the field ; and, consequently, that a change in the type of field is accompanied by a change in the type of paths. Whether the change will be great enough to produce an experimentally perceptible kink in the characteristic can only be determined by a complete theory, which I do not pretend to have given. But I contend that, when such a kink is found at the point where theory predicts the change of type (and it is so found, according to my experience, in the type of curve to which Mr. Appleton first drew attention), then it is highly probable that it represents that change of type.

This argument is not necessarily inconsistent with the presence of secondary emission for it does not assume that all electrons leave the filament. I am ready to admit that the absence of the kink at low voltages suggests that secondary emission plays some part in determining the kink. But if so it is secondary emission from the grid and not from the anode as Mr. Appleton suggests, for when v_a exceeds v_g the electrons excited at the anode cannot reach the grid, and on the other hand the theory I gave explains why the kink occurs at $v_g = 0{\cdot}8v_a$— the point above which secondary emission from the grid must cease owing to the adverse field at the surface.

A. C. Bartlett.

Research Laboratories of the General Electric Co., Ltd.,
London.
February 23rd, 1922.

Printed by the WHITEFRIARS PRESS, LTD., London and Tonbridge, and published by THE WIRELESS PRESS, LTD., 12—13, Henrietta Street, Strand, W.C. 2.

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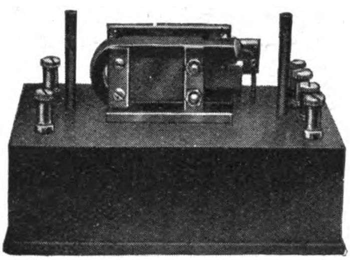

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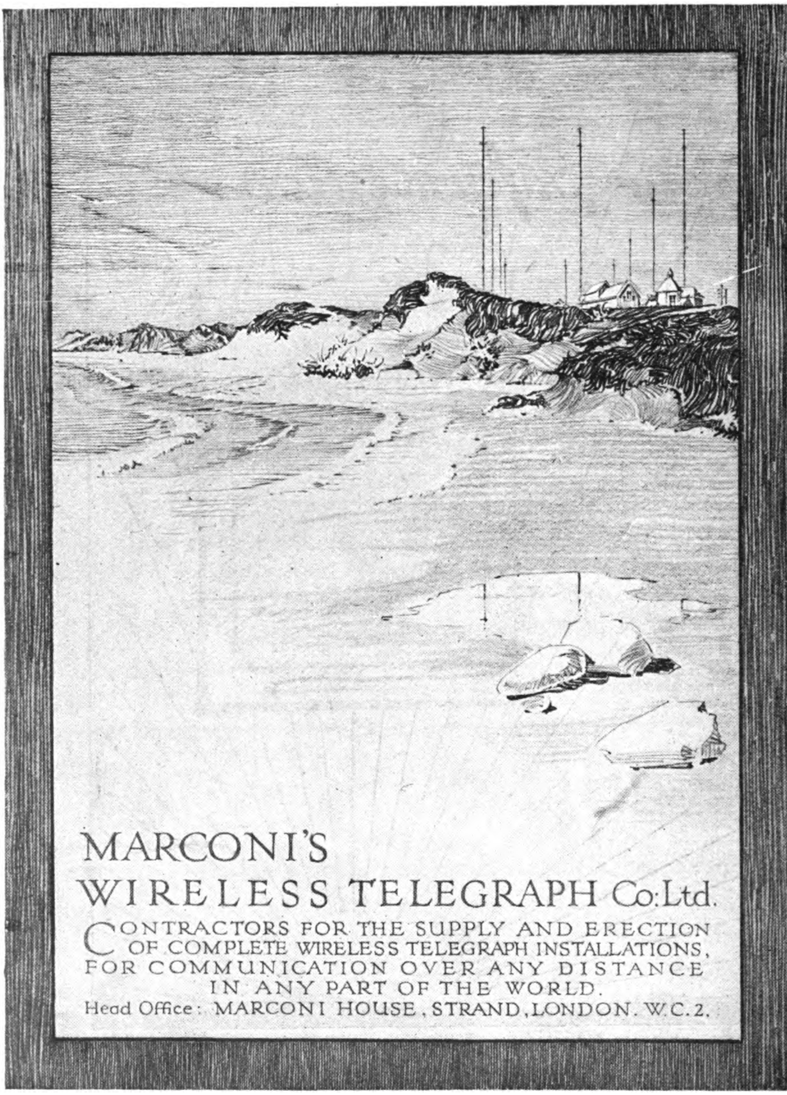
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